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APHELINUS MALI AND ITS TRAVELS.

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The world of economic entomology has known in a general way that *Aphelinus mali* Hald., a North American parasite of the woolly root-louse of the apple (*Schizoneura Eriosoma lanigerum* Hausm.) has during the past nine years been carried to many parts of the world and that in some places it has been of great help to apple-growers. But the whole story has not been told, and only a few know it in more than a fragmentary way. This is an attempt to bring all the facts together as a contribution to the rapidly growing literature referring to natural control.

The woolly root-louse of the apple (*Eriosoma lanigerum*, Hausmann), now known in this country simply as "the woolly aphis," although probably of American origin, has become a cosmopolitan pest of the apple and the pear.

Making its appearance in England toward the close of the eighteenth century, it became known as "the American blight"; and either from England or from America it has been carried to many different parts of the world, probably on nursery stock.

The question as to its American origin has probably been settled, and it is likely to have been an indigenous pest of Crataegus and to have established at a very early date an alternate food plant in the American elm.

It is probably a fair generalization to state that in the more southern part of the United States, and in British Columbia which, warmed by the Japanese current, has a mild winter, the insect lives upon the roots of its host plants, causing swellings and other deformations and interfering seriously with the sap flow. In such regions also a certain number of the lice are to

be found above-ground on sprouts from the main trunks of the trees. Following out this same generalization, in the more northern part of the United States root damage is very rare and the above-ground individuals are almost the only ones found. Perhaps climatic conditions, however, do not control, but rather soil conditions. In sandy, easily permeable soil, the root form abounds, and it is a question whether such soil is at all well adapted to the growing of apple orchards. Surely in other parts of the world the above-ground individuals prevail and often do serious damage.

Throughout the apple-growing regions of the central strip of the United States, the woolly root-louse has an important parasite, a minute Chalcidid fly known as *Aphelinus mali;* but this important parasite, from the very nature of its structure, is confined in its parasitism to the above-ground individuals of the woolly louse—it cannot penetrate the earth to the root forms.

This parasite, therefore, is not of especial importance in the apple-growing regions where the work upon the roots is the important damage to the orchards, although even here it fills a restricted role of usefulness in parasitizing the small proportion of the lice which are to be found upon suckers and in knotholes in the trunk.

But in Europe, in parts of South America, in New Zealand, and in localities in South Africa, where the greatest damage is done by the aphid above ground, this parasite bids fair to be of great assistance to the growers of apples and pears.

The woolly aphis, when it occurs above ground, is destroyed by a large number of predatory insects, just as are other aphids, notably the larvæ of Syrphus flies, the so-called aphis-lions (larvæ of Chrysopa and Hemerobius), and others; and these predators frequently destroy the aphids in midsummer rather completely, destroying at the same time any parasites that they may contain.

Although I studied *Aphelinus mali* as early as 1879, when I found it parasitizing woolly aphids on the suckers of certain Russian apple trees grown upon the grounds of the Department of Agriculture at Washington, I never thought of it as an important enemy of the species, from the fact that it did not touch the aphids really responsible for the great damage, namely, those on the roots.

Dr. Paul Marchal, however, with his knowledge of the damage done by this aphid to the apple and pear trees of France, largely above ground, began to show an interest in *Aphelinus mali* and the possibility of its acclimatization in France, as early as 1910. No attempts to send living parasites to him were made, however, until after the close of the World War; and the first attempts, by mail, were unsuccessful.

A successful attempt, however, was made in the summer of 1920. The details of this are rather interesting.

Dr. A. C. Baker succeeded in getting together several lots of apparently parasitized aphids from both apple and elm trees at Vienna, Va., and these were packed in five small boxes wrapped together. The writer was about to visit Europe, and took them with him. There were some necessary changes of temperature on the journey. I started from Washington on May 14, and the package remained at the current temperature over night on the window sill of a room in a New York hotel. We sailed on May 15, and the package was put in charge of a steward who kept it in the cold room of the steamer and reported temperatures daily ranging from 37½° to 40° (F.). Arrived in London late at night on the 24th, and the package again remained on the window sill of my hotel room. On the morning of the 25th it was taken to a fishmonger's and kept in his cold room while the writer attended certain scientific conferences in London. On Saturday, the 5th of June, the package was taken from this cold room at night; was again left upon the hotel-room window sill during the night, and on Sunday, the 6th, was carried with my personal luggage to Paris; arrived at Paris about four in the afternoon and was met by Doctor Marchal. We proceeded immediately to his laboratory where he had prepared certain small infested pear trees under gauze covering. The boxes were opened, and the contents were shaken out on blotting paper. A large number of the Aphelinus had emerged during the journey, and were dead. Not one was alive.

This was a great disappointment to the writer and to Doctor Marchal and his assistants. However, the material was all placed under the covering of the little infested pear trees and watched daily by a laboratory assistant. It was feared that the opportunity had been lost, and that all of the parasites had emerged during the warmer periods of the journey.

After three days in Paris, Marchal and I started on a journey to the south of France. On the 19th of June, while at Montpellier, we received a telegram from Paris stating that eleven living parasites had emerged from the remaining aphids. On the 24th another telegram was received, at Menton, stating that thirty more living specimens had issued.

From Menton, I went down into Italy while Doctor Marchal returned to Paris and began at once to attempt to colonize the parasites. From that time there was no difficulty; and when I made my final call at Marchal's country place at Antony near Paris, the first week in August, the great-grandchildren of the parasites I had brought over were swarming almost by the million in the large cages that had been erected for them and in the open among the woolly aphids fixed to the trunks and branches of both apple and pear.

Since that time the species has perpetuated itself in France. Its numbers have been greatly reduced each summer by a scarcity of food, the work of the predators of the aphids having been so complete. But colonies have been sent to several points in France where regional laboratories exist, and the Aphelinus at this date of writing (December, 1928) may be said to be a permanent element of the French fauna.

It is a simple matter to carry plants from one part of the world to another, even from the north to the south. Such a plant has comparatively a long and progressive life, and the only factor to be considered is its ability to grow in the new environment. But with insects the case is different. The life of the individual is short, even from the egg to the death of the adult, and each species has become accustomed to the seasonal changes in its original home. Therefore, while it is comparatively easy to carry insects from one country to another if they are in what may be termed parallel life-zones, or rather regions having nearly the same seasonal changes, it is a very different thing to carry them with hope of success from far above the equator to far below the equator (or the reverse), since the seasons are diametrically opposite; and an insect starting from New York at the beginning of winter will arrive at, say Rio de Janeiro, in the middle of the summer, a fact which one would naturally expect to be rather disturbing to the insect's economy.

But it turns out that there are certain species which can endure this radical change of habitat apparently with perfect equanimity, and this Aphelinus, fortunately, turns out to be one of these species. In fact, rarely in the course of all of the work in the carriage of parasitic insects from one country to another that has been carried on here and there for over forty years has a parasite been found that is as useful and adaptable and as potentially cosmopolitan as *Aphelinus mali*.

Following the successful introduction into France just detailed, sendings were made by the Bureau of Entomology to Uruguay and New Zealand and by these countries and France to other countries.

Although the specimens carried to France were all collected at Vienna, Virginia, by Dr. A. C. Baker, those sent to South America and New Zealand came from various sources in the United States. The following entomologists collected infested apple twigs and sent them to Washington, either to Doctor Quaintance or to Doctor Baker, and they were then sent abroad either by these gentlemen or by myself:

B. A. Porter, Wallingford, Conn., and Vincennes, Ind.
D. Isely, Bentonville, Ark.
E. R. van Leeuwen, Cornelia, Ga.
G. A. Runner, Sandusky, Ohio.
W. F. Turner, Blue Ridge, Ga.
A. J. Ackerman, Bentonville, Ark.
E. J. Newcomer, Yakima, Wash.

In addition, material was sent which had been collected by P. W. Mason, at Arlington, Va., and by E. H. Siegler, at Sligo, Md.

Table I shows these countries alphabetically. It indicates whence and when they received the parasites, and the results so far reported. The pages that follow the table consider each of the countries separately, and again in alphabetical order.

TABLE I.

COUNTRY	WHENCE RECEIVED	WHEN	RESULTS
Argentine	Uruguay	Jan., 1921	Well established. Excellent results.
Austria	No infor.	No infor.	No information.
Australia	New Zealand	1922–23	Doing good work at many points.
Belgium	No infor.	No infor.	No information.
Chile	Uruguay	1922	Well established in 1927.
England	France	1923	"Usefulness very limited." (Fryer).
France	U. S. A.	June, 1920	Well established. Effects variable.
Germany	Uruguay	1923	Apparently established.
Holland	France	1924	Widely distributed and well established.
Italy	France and Uruguay	Jan., 1921	Well established. Doing excellent work in northern and central Italy.
Japan	U. S. A.	1926	Failed to establish.
New Zealand	U. S. A.	1921	Complete success reported by 1925.
Poland	England	1928	Too early to announce results.
South Africa	U. S. A.	1920	Variable results—some apparently very good.
Spain	Italy and Uruguay	1926	Last reported results far exceeded expectations.
Switzerland	Germany	1923	No recent report.
Uruguay	U. S. A.	1920	Great success. "Woolly aphis well under control."

ARGENTINA.

In the early spring of 1921, Dr. Roberto Sundberg, the Chief of the Defensa Agricola of Uruguay, sent to the Defensa Agricola of Argentina a colony of the Aphelinus. Doctor Sundberg had received original living material from the Department of Agriculture in Washington in January, 1921. Señor E. E. Blanchard and Ing. Carlos A. Lizer y Trelles, acting for the Argentine organization, started these colonies in the fruit-growing region of the so-called delta of Argentina. The results were very satisfactory, and the following year they established the parasite in all of the principal apple-growing regions of the district.

The Sociedad Rural of Argentina also introduced the Aphelinus from Uruguay, in the early part of 1922, under the auspices of the Biological Institute of the Society. The

material was placed largely in charge of the late Señor Juan Bréthes, who reported in the Annals of his Society of the 15th of March of that year that there was every indication that it had proved effective and that parasitized material was then being distributed.

Since 1922 no further introductions have been made. Señors Blanchard and Lizer y Trelles have made numerous inspections from time to time, and I learn from correspondence with Señor Blanchard that it may safely be stated that the results obtained have been for the most part extremely satisfactory. He wrote me in July, 1927, that in the Delta region the parasite seems to find ideal conditions and that it was at that time difficult to find a living woolly aphid. He said further that the varieties of apples that were abandoned prior to 1921 on account of their susceptibility to attack by the woolly aphis, were in 1927 grown with impunity. However, the pest had not entirely disappeared. He stated that in the springtime it was not uncommon to find an occasional small colony on the main trunks of the trees close to the ground. These, of course, were established by migrating root forms, and were soon destroyed by the parasites. This excellent condition had been observed in all of the apple-growing regions of the province of Buenos Aires, as well as in the littoral zones. Elsewhere, as in the Rio Negro district and in the apple-growing regions of Mendoza and San Juan, the results had not been so good. Possibly the high altitude or the cold winters or the scarcity of alternate hosts may account for this difference. Nevertheless, even in the regions indicated the parasite was said to be doing good work, and it was Señor Blanchard's hope that it was possibly developing a resistant strain which will be able to withstand the unfavorable conditions.

AUSTRALIA.

The Aphelinus was not sent direct from the United States to Australia, but after its establishment in New Zealand by Doctor Tillyard and his assistants it was sent to the former country from the latter. In his report on the work during the season of 1922–23, Doctor Tillyard wrote that Australian applicants would be supplied with infected twigs sent out during the winter (July) by post. He urged all New Zealand orchardists who apparently had already a good supply to help their Aus-

tralian friends by sending them twigs bearing parasitized aphis.

Through consignments which were sent by Doctor Tillyard to Western Australia and Queensland, the species was successfully established, and the work of distribution to orchardists in those two states was carried on during the summer of 1924.

It is very interesting to note that, although a consignment was sent to New South Wales, it was lost through over-strict application of quarantine regulations. Further supplies were sent, however, during the winter (July-August, 1924).

The earliest report from Queensland seems to have been published by Mr. H. Jarvis in the Queensland Agricultural Journal for May, 1924. He states that, accompanied with Mr. A. A. Girault, he visited Stanthorpe where more than fifty parasites had been liberated. They found other parasites some distance from the tree on which the first consignment was liberated, and concluded that the parasite had become established.

In Leaflet No. 128, Mr. L. J. Newman, Government Economic Entomologist of Western Australia, describes the introduction into that state, describing the liberation of the parasites on August 31 and September 28, 1923. The first generation from these emerged October 23, and within three months there was an almost total parasitism of the visible aphids on the original tree. Later the parasite was found one hundred yards away. On the 27th of January, 1925, Mr. Newman wrote me that the parasite was established in almost every apple-growing area in the state.

In the Journal of the Department of Agriculture of Western Australia for December, 1926, Mr. Newman stated that *Aphelinus mali*, after a year, parasitized nearly all the "black citrus aphis (*Siphonophora* sp.)." I questioned this statement at the time, and Mr. Newman promised to send specimens but none have ever come. Doctor Tillyard, in Washington, in June of 1928, said that Mr. Newman had also promised to send him specimens, but that he had not received them. I believe that all of the records of the rearing of *A. mali* from aphids that have not a waxy covering are due to wrong determinations.

In Queensland the good work of the parasite continued and spread. Mr. R. Veitch, in his Report of the Chief

Entomologist (Report of the Department of Agriculture of Queensland, 1926–27, Brisbane, 1927) wrote, "*Aphelinus mali* Hald. continues to be of great value in the control of *Eriosoma lanigerum* Hausm. (woolly apple aphis)."

In 1926 there were several mentions of *A. mali* in Australian publications. W. B. Gurney, in the Agricultural Gazette of New South Wales, February 1, 1926, showed that 16,000 living individuals of *A. mali* had been distributed in that State. H. M. Nicholls, in the Annual Report of the Government Microbiologist of Tasmania, reported that *A. mali* had been introduced from Western Australia and was apparently already multiplying rapidly and largely reducing the numbers of the aphid. In a later report, Gurney stated that arsenical sprays do not affect the parasite and contact sprays have little direct effect upon it. Where it has been introduced on one or two trees in an orchard, however, these trees should be left unsprayed. He also advised that prunings of trees showing dead parasitized aphids should be kept to start fresh colonies of the parasite in the spring.

In Queensland, remarkable success was reported in 1925, Mr. Jarvis stating that the parasite had been found as far as three miles from the point of liberation. However, he made a further statement that the parasite seems to attack any dark-colored aphid. This appears to be a mistake, and the inference is that some other parasite is at work. In August, 1926, Jarvis reported that, although a few individuals may emerge earlier, the adults mostly appear about the end of August and the parasite continues to be active until about the end of April. The life-cycle occupies about a month; so that five or six broods would be possible there during the season. He found that adults fed on honey and water lived for twenty-one days in the insectary. He makes the further interesting statement that many of the parasites hibernate in the dead bodies of the aphids attached to cloth bands around the trees, and suggests that such bands, with all prunings, should be stored in a cool place during the winter and returned to the orchard in the spring.

Several interesting articles have appeared in the Journal of the Department of Agriculture of Victoria by G. T. Levick, Science Field Officer. These were summed up in one paper published in the June, 1925, number of the Journal. The original stock was received from Tillyard in New Zealand in

October, 1924. Parasites were liberated at the Burnley Horticultural Gardens, on a tree badly infested with woolly aphis, which had been especially prepared and covered with "butter-cloth." A month later another consignment was received from Newman of Western Australia. At the date of the writing of this latter article, the Aphelinus had been distributed to more than fifty orchards throughout the State of Victoria, and in practically every case of those that had been inspected the parasite was well established. Mr. Levick found the period of development of a generation to be shorter in Victoria than in New Zealand—that is to say, three weeks instead of five.

The parasite was introduced into Tasmania from Western Australia in November, 1924. H. M. Nicholls, in the Report of the Agriculture and Live Stock Department for 1924–25, states that as the adult parasites appeared they were liberated in various orchards in both the northern and the southern apple-growing districts. He stated that they took kindly to the climatic conditions and at the time of the report were everywhere multiplying rapidly. In some cases they had already reduced the woolly aphis to very small numbers. The winter was passed in the larval stage in the body of the parasitized aphid.

AUSTRIA.

In a paper entitled "Plant Protection in Austria," read at the meeting of the Deutschen Gesellschaft fur angewandte Entomologie in Vienna in 1926 (published in the Verhandlungen of the Society for 1927), Dr. Bruno Wahl mentions the damage done by the woolly aphis and states that the acclimatization of *Aphelinus mali* will be undertaken.

BELGIUM.

In his summary report of the work accomplished in his laboratories in 1925, Marchal mentions the fact that two new sendings of this parasite had been forwarded to Gembloux, Belgium, where the multiplication of the insect proceeded in a very favorable way. We have heard nothing further about the status of the insect in that country.

CHILE.

In 1923 the Defensa Agricola of Uruguay sent a colony of the parasites to Chile, and excellent results from this importation were reported by F. L. Crouse. The acclimatization was evidently accomplished without difficulty, and we have seen an article on the biology of the species by J. Torres Ortiz in *Agronomia* (Santiago, Chile, November, 1927). In this article, the author states that the females lay five or six eggs an hour, always in the early morning or towards nightfall. Most adults emerged in 20 to 29 days after egg-laying, although sometimes they were delayed until 32 to 50 days. No males had been noticed. During his study, covering two years, there had been an average of six to seven generations a year, the adults living to a maximum of 32 days. The statement is distinctly made that the winter is passed in the egg stage within the aphids that have migrated to the roots of apple trees.

ENGLAND.

In 1922, according to an interesting article by R. Stenton published in the Journal of the Ministry of Agriculture of London in 1925, it was decided to go into the experimental introduction of the Aphelinus; and in March, 1923, material was received at the Harpenden laboratory of the Ministry of Agriculture and Fisheries from Paul Marchal of Paris in the form of dried aphids containing full-fed larvæ of the parasite. According to Mr. Stenton's report, adults emerging from this original material multiplied at a prodigious rate in captivity on apple trees infested with woolly aphids during the following summer, and by 1923 it was possible to consider introductions in the open at various chosen centers. The first lot of trees at Harpenden were in pots and were kept in the insectary, and a large stock of the parasites has been maintained there ever since, a second insectary being added in 1925, according to information received from Mr. J. C. F. Fryer. Stocks were also established in insectaries at the Long Ashton Fruit Station, Bristol, and at Seale Hayne Agricultural College in Devon. In 1924, after experimentation, it was found to be the best method to send in the early spring several apple twigs bearing one hundred or more parasitized aphids, the twigs being enclosed in a cage of wire gauze with a mesh large enough to

allow the Aphelinus to escape but small enough to keep out ladybirds. With these little cages were sent instructions to tie them to the trunk or branch of trees where there was probability of a strong infestation. They were sent in all to 26 different localities.

Prior to 1928 small introductions, usually consisting of only one cage, were made in a large number of centers each spring. In 1928, however, all the material available was divided into two lots each consisting of approximately three thousand parasitized aphids, and these were introduced into single orchards at Chislehurst (Kent) and Ledbury (Worcestershire). As appears from Mr. Fryer's published report on Insect Pests of Crops for 1925-1927, issued in 1928 (Miscellaneous Publications of the Ministry of Agriculture and Fisheries No. 62), most of the introductions apparently resulted in failure. As to the remainder, although the parasites persisted for a time, in no case do they seem to have become definitely established. The greatest measures of success were reached at Broadway (Worcestershire), at Barnstaple (Devon) and Usk (Monmouthshire). Doctor Fryer concludes that the difficulties in establishing the parasites appear to be due to three causes, (*a*) The irregularity of the occurrence in England of the woolly aphis; (*b*) The tendency of the parasite to emerge too early in the spring, before the woolly aphis has become abundant; (*c*) The adverse effect of the dull, wet or cool weather prevalent in England in the spring. The adult Aphelinus, delicate creature that it is, with wings that are easily clogged by moisture, cannot spread and does not seem to multiply rapidly under such conditions. This seems natural enough, and I have always attributed the abundance of aphids in the wet springs in the United States and their disappearance in hot weather partly to the fact that their effective parasites of the Braconid subfamily Aphidiinæ cannot move about with moisture-clogged wings.

Doctor Fryer concludes from the work so far done that the usefulness of this parasite under English conditions will be very limited.

In a letter received from Prof. F. V. Theobald, of Wye (Kent), the same point was advanced, although Kent is I believe one of the sunniest counties in England. Under date of June 19, 1928, he wrote, "I am sorry to say, *Aphelinus mali*, which I turned out under favorable conditions, has been a failure.

Definitely it is no good in this part of England. In one orchard it spread to a few trees near at hand, and then died out; in the other it was even worse. I gather that it has been no good anywhere in this unkindly climate."

FRANCE.

The first efforts to acclimatize the parasite in France, after I carried it over successfully in the summer of 1920, were in the neighborhood of Paris. Centers of rearing under control and of dispersion were started at Antony, at Bourg-la-Reine and Montreuil. Soon the entomological stations in the provinces were sent colonies which allowed them to rear the parasites successfully. Every year afterwards from the different centers, especially from Paris, sendings were sent to correspondents in the different provinces or in other countries.

The testimony as to the results obtained down to 1923, when Doctor Marchal mentioned the subject in his report as Inspector General, was very unequal; failures apparently resulted in some cases and successes in others. In 1923 colonies were sent out to eleven departments of France; also to England, Roumania, Algeria and Morocco. Doctor Marchal reports also that good news has been received from colonies which were established, through his assistance, in 1922 in Switzerland (Lausanne) and in Italy (Florence).

In an interesting report published in 1924, entitled "The Acclimatization in Normandy of Aphelinus mali," by R. Regnier, we find the following account (fully translated):

Biology of the Aphelinus.—The female of the Aphelinus punctures successively a certain number of plant-lice and lays in each one an egg which gives birth to a larva which feeds upon the internal organs of the plant-louse. Marchal estimates 60 as the minimum of the offspring of a single female. A parasitized plant-louse speedily loses the waxy filaments, turns black, and dries up, without any especially noticeable deformation. It is necessary to know this aspect of the plant-louse when one is attempting acclimatization. One must not take as parasitized plant-lice those adults which, under the influence of different conditions, have lost a large part of their waxy covering. *The parasitized woolly aphis becomes plainly black.*

One must not take for parasitized woolly aphids green plant-lice parasitized by Aphidius. Green plant-lice, as a matter of fact, are often mixed with the woolly aphids upon young twigs, notably in the nurseries. When these are parasitized they assume a characteristic inflated condition and become gray in color.

At the end of 20 days—sometimes more, according to the season—one Aphelinus issues from each parasitized aphis. Nothing is easier to recognize than the empty aphids. They show a circular hole pierced by the Aphelinus in issuing, and this is visible to the naked eye.

The life of the Aphelinus is generally short. The number of generations is seven to eight each year. In the laboratory at Rouen we have had the earliest issue in the first days of April and the last ones in October. Normally the appearance of the parasite coincides with that of the woolly aphis. Sometimes, however, it issues some weeks in advance, as happened in Normandy in 1922. The plant-lice had not yet crawled up from the earth when the Aphelinus came out, and there resulted an enormous loss of parasites, which in other cases has checked acclimatization.

The parasites fly little. They hide themselves often under leaves, and jump with the greatest facility. This makes an easy way of recognizing them without the trouble of examining their specific characters. Marchal estimates their dispersion at about 400 meters.

The parasite hibernates well in Normandy, enclosed in the plant-louse which it parasitizes and from which it issues in the spring.

Acclimatization of the Aphelinus. Rearing.—The acclimatization of an insect parasite of the size of the *A. mali* must be undertaken with certain precautions based upon its biology and upon the conditions under which the woolly aphis lives.

The rearing is now going on by the entomological stations at Paris, Chalette-Montargis, Rouen, Saint-Genis-Laval and Bordeaux, and, by correspondence, these stations are doing what they can to create on all sides, at places where the woolly aphis is most abundant, centers of acclimatization. It is important to increase the number. All groups of agriculturists and horticulturists who are interested in the fight against the woolly aphis should organize a center of rearing which would be able to supply the needs of the region.

The rearing of Aphelinus is made in large cages of wooden framework with tarlatan sides, two or three meters long, one and a half meters broad and two meters high, in which should be placed a certain number of small apple trees well stocked with woolly aphis. These cages should be installed in winter, and the trees would better be planted in October. The Aphelinus in the parasitized aphids will come on twigs which should be bound with raphia to the enclosed little apple trees. The woolly aphis, thus being protected from the attacks of its enemies, develops with great rapidity, and the Aphelinus parasites which come out find abundant host material, multiply, and it soon becomes possible to create thus centers of dissemination. Besides this, thanks to the small mesh of the tarlatan, only the parasites can escape from the cage, while the aphids remain enclosed.

Instructions for dispersion.—If the rearing of Aphelinus necessitates certain material and certain expense, it is not so with dispersion. It is necessary to adopt a simple and practical method without expense. In order that the chances may be best, it is necessary to find a place in an orchard especially invaded by the woolly aphis and which will have

plenty of material during a great part of the year for the Aphelinus which exclusively attacks this aphis. On the other hand, it is necessary to take certain precautions. Abandoned nurseries, badly cared for gardens, old neglected wall tree, where the aphis is generally increasing will be the most favorable places and should be sought for. Lacking such infested points, the orchardist should use the trees on his own property, choosing those that are most attacked.

The most necessary precautions are as follows:

(1) The twig covered with parasitized aphids should be carried or sent in a box or tube, and should be opened only near the place of acclimatization so that the Aphelinus which have issued during the journey will not be lost and can parasitize some colonies.

(2) This twig should be carefully bound with raphia to a branch covered by the woolly aphis.

(3) One should make certain that there are upon this branch no larval or adult Coccinellids nor Syrphid larvæ nor Hemerobiid larvæ, since all these insects are great feeders on plant-lice. It is necessary to search for such enemies and to remove them with fine pincers or with a dissecting needle.

(4) To protect the whole initial experiment, a sack of muslin or tarlatan should be made. This precaution is absolutely indispensable in order to keep predators away from the colony. Experience has shown us that it is necessary to give to this sack a certain rigidity so that it will not be injured by rain or wind. A cylinder should be made with about 40 square centimeters of the muslin, and this should be kept open by a wire drawn in a circle at each end, the two being connected by wire; then, beyond each circle the muslin is fastened to the twig.

When the Aphelinus come out of the parasitized aphids a certain number of them will find that the colony offers a favorable place for their development and will lay their eggs in the aphids. A center is thus established, and the Aphelinus will multiply, and, escaping through the mesh, they will parasitize colonies of woolly aphis on the surrounding trees.

The best time to begin this work is the end of April and during the month of May. In June there are generally plenty of woolly aphis, but that is also the month in which the greatest number of predators appear. If the attempt at acclimatization is made during this month, the Aphelinus, needing several weeks to thoroughly establish itself, will in July no longer find sufficient hosts for multiplication. During certain years when the predators are very numerous, the acclimatization, after a promising beginning, may find itself compromised by an insufficiency of hosts.

There is another method: that of *fixation*, similar to that which we have just described, which has for its end obliging the Aphelinus to remain upon a fixed branch. This method takes more care, but it is nevertheless very simple. We recommend the operator to have at his disposal several branches covered with parasitized aphids. One of these branches should be enclosed as we have indicated, but, in place of using *toile a patrons* or tarlatan, one uses *toile a beure*, or, better still, muslin, where the mesh will not permit the Aphelinus to get out. After

twenty days, this sack should be changed to tarlatan so that the Aphelinus which come out of the newly parasitized aphids can escape and propagate in neighboring colonies. After fifteen days in summer one can see the parasites come out of the plant-lice, and if one or two of them are placed upon a bit of white paper, and if they are black and yellow, and jump, they are without much doubt the Aphelinus.

We have the firm hope that some day the raising of Aphelinus will be done on a large scale and that the centers of dispersion will be numerous, and that the acclimatization of this precious parasite in France will be of some use. But we must not forget that in the acclimatization of Aphelinus we are only adding a new enemy to those which we already had, and consequently we must not be astonished if at certain times, in spite of its help, the woolly aphis will reappear, perhaps even abundantly, during intervals, after which its enemies will in their turn dominate. This is the normal cycle of indigenous pests which have for a long time had their predators and their parasites.

Conclusion.—From all that we have said, it is reasonably sure that henceforth the acclimatization in France of ***Aphelinus mali*** may be considered as possible; that this parasite withstands our winters very well and multiplies very rapidly when there are abundant colonies of the woolly aphis at its disposition; but that its introduction into our country is still too recent and the number of centers too small to estimate positive results which may come about. It is necessary to leave the entomologist time and material for observation before announcing to agricultural organizations the best ways to popularize the method, to create centers of rearing without which the dispersion of the parasite will never be possible.

This study has no other end than to sum up the condition of our knowledge upon this question and to show the real importance which this new attempt may have some day.

Ever since the first successful introduction in the summer of 1920 Marchal has been rearing the parasite in cages at his country place at Antony and has been making careful studies of its biology. It is hoped that he will publish a full monograph.

On September 3, 1928, he wrote me, in the course of a personal letter:

> While waiting to join Madame Marchal in the country, and in order to get exercise, I made during recent dates long walks in the country around Antony, having for my object to determine the area of dispersal of the Aphelinus. I have been surprised to find that the present summer, hot and dry as it was, has been very favorable to this dispersal. Upon all the apples, where there had been the least trace of the woolly aphis, I have found the Aphelinus in all the communes about Antony and Bourg-la-Reine—that is to say, over a territory having a diameter of eight to ten kilometers. The acclimatization of the species, therefore, has been very well effected in this region to the south of Paris, and it is probable that the area will be enlarged without cessation. However, this will necessitate seasons which are more or less favorable.

GERMANY.

In one of his publications, the Italian writer Malenotti speaks of a correspondence with Stellwaag of Germany in which the latter states that the first attempts at the establishment of *Aphelinus mali* in Germany failed during the first winter from the results of severe cold, the inference being that the species will not stand a temperature of 10° (C.). And on this statement of Stellwaag's, added to his own experience in north Italy, Malenotti advises the keeping of colonies under glass, as we have indicated in our consideration of the Italian work.

The best published information on the subject of the German experiments is contained in an article entitled "The Introduction of Aphelinus mali," etc., by R. Schander and O. Kaufmann in the Zeitschrift für angewandte Entomologie, 1925, part 3. The experiments were carried on apparently at Landsberg in Bavaria.

The material was received early in September, 1923, from Uruguay. No adults had issued during the journey. Three days after arrival, however, the first ones emerged (The shipment had been kept in the refrigerating room of the steamer). In their rather long article, the German writers describe the oviposition with great care and state that experiments with other aphids than the Schizoneura were unsuccessful. The different stages are described, and it is stated that the males appear somewhat earlier than the females and are smaller in size, but considerable variations in size occur with both sexes—sometimes small females are smaller than large males. The first generation in the spring occupies four weeks. In summer a generation may be completed in 14 days. The adults mate soon after emerging and begin to oviposit immediately. The generations overlap during the summer, and an exact record is difficult. The authors think that ten generations is not an exaggeration.

The parasite hibernates as a larva in its host, development slowing down in the fall. In non-heated greenhouses, the first parasites emerged, in 1924, during the middle of April; in 1925, at the end of March. In the open field the first adults were noticed, in 1925, on April 24, at a date when the second generation had begun to lay eggs in the greenhouse. Investigation showed that the period of hibernation could be extended or shortened without injury to the larvæ.

Some interesting observations were made upon the parasitized aphids. The writers state that as soon as these feel that they are mortally affected they separate from the colony in order to hide in cracks beneath scales of bark, or in holes or wounds on the branches. They have often been observed to migrate as far as one meter, and the statement is made that they may leave their old host plant. After a suitable place is found, they are said to fasten themselves to the tree by means of a web or sticky substance so that they are rarely washed off by rain or blown off by the wind, while their natural enemies are not likely to locate them in their hiding places. Part of the parasitized aphids migrate, like the healthy ones, to the roots and seek the covering protection of the soil.

The authors consider the prospects of acclimatization to be very bright, but state that several more years must elapse before assuredness. They consider that the radius of activity and the speed of distribution are very small. The maximum increase of the aphis is certainly much greater than that of the parasite. The writers believe that the growth of resistant varieties of apples is still to be encouraged, but think that the acclimatization of the parasite will be worth while. They do not look forward to a lasting and complete success if the parasites alone are relied upon.

HOLLAND.

In 1924 the Bureau of Plant Diseases of Holland (headquarters at Wageningen) imported a small colony of *Aphelinus mali* from France. In his report for 1925, N. van Poeteren stated that the parasites survived the previous winter and were increasing at the time of writing.

In 1928 the report of the Bureau affirms that the importation was a complete success. It not only had established itself in Holland, but had been distributed to a number of different sections. The demand for the parasitized aphids soon became so great that it was impossible to fill all requests. However, ninety shipments were made, distributed over eighty districts covering the entire country. The results of careful observations made in 1927 indicate that although the parasite had not established itself in all places as well as it did in Wageningen and Lunteren, it had nevertheless surpassed all expectations. It was assumed that it had taken firm hold in places not yet made public.

ITALY.

In 1921 Prof. G. Del Guercio, of the Royal Entomological Station at Florence, imported *Aphelinus mali* from France. His original specimens were received on the 20th of September from France, Gaumont, one of Marchal's assistants, having been sender. A second sending was received at Florence in 1922 from Uruguay and was placed in the garden of the Station. In this garden and in the laboratory, the parasite was studied carefully for a number of years by Del Guercio. In the meantime the French sending had been placed in the orchard of the School of Horticulture and Fruit Culture in Cascine.

The species multiplied rapidly, and different specialists connected with the Traveling School of Agriculture started centers of distribution at various points in central and northern Italy. Prof. E. Malenotti began to publish on the results in 1923, and has since issued numerous papers. He found that in northern Italy the winter of 1923-24 was very severe and the parasites were greatly reduced in numbers by the cold except for favorable localities where special conditions of protection existed. By correspondence with Doctor Stellwaag, of the Agricultural Institute of Neustadt, he learned that exactly the same thing had happened in Germany. He therefore recommended, in a paper published in 1924, that in northern Italy there should always be kept a small supply of very young apple trees infested by parasitized Schizoneura, under glass—in greenhouses or in cold-frames. He recommended for this purpose young Calville stock (except the red winter variety) or Golden Reinette or other varieties peculiarly subject to attack by Schizoneura. He recommended that young trees should be taken in the middle of November and placed in unheated greenhouses. Tests showed him that a temperature of 10° (C.) stopped the development of the larval parasites, which is resumed the following spring, the first adults appearing about the middle of April. He pointed out that all the other natural enemies of the aphids should be destroyed on these young plants. He indicates that their presence is easily noted by the disorder in the Schizoneura colony; where they are present, there remains usually only a scattered area of waxy exudations. As apple trees are not planted in Italy in large orchards, Malenotti states that it is necessary to stock many centers.

Following the cold winter above mentioned, the parasite was again introduced into northern Italy in 1924, and complete reproduction was established in those regions, namely Trentino and Alto Adige.

In one of his papers (published in *Il Coltivatore* of the 20th December, 1924) Malenotti described a migration of 12 kilometers by the Aphelinus, the parasite having been found at Desenzano, 12 kilometers from a center in Moniga del Bosco. He considered it largely a matter of wind-spread. I wrote Malenotti on the receipt of this paper and suggested the accidental carriage by some person or persons; for example, one or more of the little parasites might have become attached to the clothing of a man walking through the orchard at the center of distribution, and later, finding themselves at this distance of 12 kilometers in an infested orchard, the parasites, attracted by the aphids, might have left him there. Malenotti wrote in reply that there are hardly any movements of persons or cars between the two places.

In 1925, after careful study of the parasite, Del Guercio issued a long and important paper entitled (translated) "New Contributions to the Study of the Woolly Root-Louse and its Internal Parasite." This publication, which covers 35 pages and carries numerous illustrations, is obviously the result of close and long study. In the course of this study many important points were brought out. One of the most interesting was the discovery of apparently two forms of the Aphelinus; the one smaller, which he calls the advance guard, since it is more active and is the form that spreads the species by means of flight; the other larger and more sluggish, appearing after the first invasion of a new colony of the aphid. To one of these forms he has applied the name *Aphelinus mali* Hald., variety *italica* Del Guercio. His descriptions of the two forms indicate not only differences in size but also differences in the proportions of the antennal joints. Judging by the figure on page 23, the variety *italica* is the smaller "advance guard" form, a figure (13) on Plate III obviously representing the larger and more sluggish form. As it happens, however, the so-called new variety to which he has given a special name seems to be the typical form as found in the United States. His observations on the habits of the so-called "advance guard" are interesting. In another publication he reports that, in a single place, he found that the Aphelinus had migrated over 400 meters across high walls and

over tall trees. Malenotti, referring to this observation, has stated that he himself at Vicenza noticed a spread of 300 meters. Another interesting illustration of migration is told by Malenotti in *Il Coltivatore* for October 10, 1924. It seems that his friend, Prof. C. Malandra, during the first part of June, started a colony at Lendinara. A few small branches carrying parasitized aphids were placed upon a few low-growing apple trees which were trained along a horizontal wire. Less than 3½ months later Malenotti visited the orchard and found that the Aphelinus had become strongly established on tall apple trees fifty meters away and had destroyed nearly 80% of the heavy infestation. Hundreds of thousands of aphids had been killed.

Curiously enough, Del Guercio's figure of his variety *italica* represents exactly the series of males of *A. mali* in the collection of the National Museum, Washington, whereas the form figured on Plate III corresponds exactly to the females in our collection.

In 1921, Prof. F. Silvestri at Portici wrote me for specimens. Knowing that he could get them much more quickly and with less danger of loss on the journey from Doctor Marchal in France, I referred him to the latter. He received specimens from France on July 5, 1922, placed them on badly infested trees in the experimental orchard of the Agricultural School, and a month later specimens of the first Italian generation issued. From these trees in 1922 and 1923 Doctor Silvestri made sendings of the parasite to Caserta, Benevento and to Salerno, localities not far from Naples and lying to the north, the east and the southeast of that city. The species was everywhere very easily acclimatized, but, Silvestri writes me, "Where Schizoneura has very favorable conditions of development the parasite has not controlled the pest."

It seems, then, that the species has been established thoroughly in Italy and that, with some care to maintain numerous centers of supply during severe winters, it will continue to be of great assistance to fruit growers. It is not likely, however, that it will prove as perfect a protection against Schizoneura as does its relative, *Prospaltella berlesei* Howard, against the white scale (*Diaspis lanatus*). The constant renewal of the above-ground form of the Schizoneura from the underground root-form and the fact, pointed out by Lundie, of the continued reproduction of the aphids for some days before the parasitism becomes effective account for the difference in effectiveness of the two parasites.

JAPAN.

Two attempts have been made to acclimatize the Aphelinus in Japan—one in 1925 and the other in the winter of 1925-26. The first attempt failed. The receipt of the second sending was acknowledged on April 20th by Professor Kota Monzen of the Imperial College of Agriculture and Forestry at Morioka. They were apparently in living condition. But as we have heard nothing further the probabilities are that again the establishment failed.

NEW ZEALAND.

The story of the introduction of the Aphelinus into New Zealand has been well and fully told by Dr. R. J. Tillyard in the New Zealand Journal of Agriculture for July 20, 1921. Tillyard and I had met in the summer of 1920 in London when I had in charge the consignment of living Aphelinus for France. Returning to New Zealand via Washington before my return, Tillyard arranged with Doctor Quaintance of the Bureau of Entomology to have parasitized woolly aphids collected in the autumn and forwarded to New Zealand. On the 11th of January, 1921, the consignment reached Wellington, and on the 13th of January arrived at Nelson. The consignment contained specimens from the State of Washington, the State of Connecticut and the State of Arkansas. From this lot eighteen living specimens were reared during the month of February. These were placed in different orchards, under gauze. All the colonies failed except one consisting of three males and two females reared on the 19th of February. Early in April adults of the first generation on New Zealand soil began to appear. Doctor Tillyard describes his methods and the disposition of those first appearing. Cold weather put a stop to the breeding early in May. The first New Zealand brood consisted of 142 specimens, the offspring of the three males and two females above mentioned.

In 1922 he published another statement, showing a much greater amount of rearing and distribution in the summer of 1922-23. Again, a year later (1923) he showed a distribution in one province of 5,255 specimens; in another of 6,620 specimens; in another of 15,055 specimens; in a fourth of 2,300 specimens, and in a fifth of 3,825, making a total of 33,055 distributed.

A year later (1924) there was a great increase in the distribution work, and the significant statement was made that "Only three years from the date of its original introduction the parasite has succeeded in practically eliminating the woolly aphis from large areas of orchard country in the Dominion." Again, he states "The letter file devoted to Aphelinus at the Cawthron Institute is full of appreciative letters about the work done by the parasite in the orchards of the Dominion during the past year." This was notably so in the Auckland and Nelson districts.

In his report published June 16, 1925, he again gives an account of the distributions and gives a long list of the towns and the individuals to whom consignments had been sent. His total shows a distribution of 112,000 specimens.

Following his paper giving the astonishing results of the work of the seasons of 1923 and 1924, Doctor Tillyard wrote me at length about the possible parasitism of other aphids and also mealybugs, partly inspired to these questions by the observations of Newman and Jarvis in Australia. He also began about that time to speculate about the possible effect of the crossing of two geographical races of Aphelinus. He contrasted in his mind the large measure of success which he had obtained with the Aphelinus in New Zealand with the lack of success which he had had with the dipterous parasites of the European earwig which he was importing from England about the same time. He noticed that some of the parasitized material of woolly aphis from the United States came from Connecticut and some from Arkansas or Arizona, and he thinks that in the insectary these two strains may have crossed and thus produced a race of great vigor in New Zealand. Writing on May 25, 1925, he insists that the hybridization of distinct biological strains often results in improved vigor even if the original strains are not morphologically distinct. He adds, "Whatever be the cause, the fact remains that *A. mali* in New Zealand is almost unbelievably active and productive, and we all of us owe you a deep debt of gratitude for supplying the original colonies."

In his letter of August 28, he writes, "The immense success of *Aphelinus mali* both here and in Australia has quite altered the outlook for the Cawthron Insitute . . . . One man left us his estate (3,000 pounds) as an endowment for research, and another man has given us sixty-five acres of valuable land . . ."

In closing his 1925 report, Doctor Tillyard announced that the following spring and summer only a few trees would be retained at the insectarium for the purpose of raising broods of the Aphelinus and that the main object of this would be to have a small supply always on hand in case the parasite should happen to die out in any district owing to the complete destruction of its host. The announcement was made that general distribution of the parasite would not be undertaken in the future as it was then considered that the parasite was at that date sufficiently abundant in almost every part of New Zealand to make it possible for any orchardist to secure supplies locally. As above indicated, this statement was supplemented by the complete list of all applicants who had received supplies during the year. A similar list was published with the previous report.

POLAND.

According to Dr. R. Bledowski, *Aphelinus mali* was imported into Poland from England with the assistance of Dr. S. A. Neave, in 1928, and was liberated in orchards in the vicinity of Warsaw. It multiplied, but at the present time no results have been announced as to successful hibernation.

SOUTH AFRICA.

During the summer of 1920, when the writer was carrying parasitized woolly aphids to France, a South African student, Mr. A. E. Lundie, was studying at Cornell University, Ithaca, New York. Before leaving South Africa, he had been requested by Prof. C. P. Lounsbury, the Government Entomologist of South Africa, to make the attempt to send *Aphelinus mali* to that country. Mr. Lundie made the necessary studies at Ithaca and sent parasitized aphids to Pretoria, where the parasite at once took hold, laid its eggs in native aphids, and soon a new generation began to appear. Distribution of parasitized aphids followed during the next two seasons.

On the 30th of June, 1923, Professor Lounsbury reported as follows:

> The distribution of the woolly aphis parasite (*Aphelinus mali*) was continued. Following hailstorms, apple trees in Pretoria, in which the parasite had been established for two years, became heavily infested with the pest insect early in the season, despite its enemy. But as soon as the season advanced the parasite caught up on the aphis and, when winter approached, few live aphis remained, while the trees

were thickly studded with the blackened bodies of victims of the parasites. The parasite was found to spread quickly from garden to garden. It was observed well established about five miles away from where any specimens were liberated.

In 1926 Professor Lounsbury reported that the parasite was spreading naturally in many localities but had failed to establish itself in the Cape Peninsula. He stated that "The parasite is ineffective in the spring but may control the root-louse by midsummer and so check outbreaks in seasons and places where the lice are not killed naturally by heat."

In the Journal of the Department of Agriculture of South Africa for March, 1926, the statement was made that *Aphelinus mali* was found abundantly attacking the woolly aphis in the Orange Free State. This was considered remarkable as the parasite had apparently never been introduced into that region.

In June, 1928, Mr. F. W. Pettey of South Africa called at the Bureau of Entomology in Washington, and stated that the Aphelinus had had its ups and downs in the Cape State; that it still exists there and is frequently abundant and again nearly absent. The root form of the woolly aphis occurs there as well as the above-ground form. He said that at a higher elevation in a certain orchard the parasite is claimed by a certain fruit-grower to do excellent work. Farther up country a certain owner of a large apple orchard told him that the parasite was doing good work, but on further inquiry the fruit-grower admitted that he was spraying one or more times with nicotine solution.

In a letter received the end of July, 1928, Professor Lounsbury reviewed the situation in the following words:

> The insect was quickly and widely established by the material sent by Lundie. My impression is I reared about 11,000 adults from it and the emergences were in early summer when the opportunities were at the best. The rapidity with which the insect spread itself about the country was truly amazing. It was soon found scores of miles from where any were known to have been liberated, and I have come across it in house gardens on lonely stock farms separated by miles of open grass veld from other gardens—owners knowing nothing about it or even the host and hence deliberate introduction being quite improbable. However, it has not, so far as I know, become established in the warmer parts of Natal (I have found it in northern Natal, but in high country); and it does not seem able to maintain itself in the Cape Peninsula nor, according to what R. W. E. Tucker, formerly entomologist at Capetown, has told me, in some other localities in the southwestern districts of the Cape Province. Perhaps an absence of frost is unfavor-

able to it. It thrives very well here at Pretoria, but we have a little frost, although we can grow poinsettia and hibiscus in the warmer parts of our home gardens. I fancy that in the warmer parts few survive the winter owing to emergence during that season. Towards winter here it is common to see apple trees studded with thousands and thousands of parasitized woolly aphids, but by the time the trees begin to burst their buds very few parasites remain. I have found adults on the trees in all the winter months.

Personally I am not at all sure the insect is of much importance. It certainly makes a great showing after about Christmas, but its host gets weeks ahead of it before that and I would expect a very heavy mortality from heat amongst the aphids soon afterwards were the parasite not present. The woolly aphis varies greatly in prevalence from year to year, but taking several years together it seems to me the insect is in as much evidence as before the introduction of the parasite. However, some orchardists think the parasite of great benefit.

Before making his original sendings from Ithaca, New York, to South Africa, Mr. Lundie made a careful study of both host and parasite at Ithaca, and his results were published eventually in August, 1924, as Memoir no. 79 of the Cornell University Agricultural Experiment Station. In his historical review he brings out the interesting point that *Aphelinus varicornis*, described by Girault in 1909 as parasitic upon *Schizoneura crataegi* in Illinois, is undoubtedly a synonym of *Aphelinus mali*. Mr. Lundie made careful studies of the life history of *A. mali*, and describes and figures egg, larva, pupa and adult. He found that at Ithaca the total life cycle from egg to adult extends from 20 to 25 days and that the larval stage occupies from 10 to 12 days. The attachment of the parasitized aphids to bark, noted elsewhere, is according to Lundie due to a liquid that evidently oozes through part of the body while in contact with the twig or other parasitized aphid, and hardens, thus attaching the aphid firmly.

He found that the adult females lived from 11 to 39 days and that they deposited from 48 to 140 eggs each. Parthenogenesis was observed, but abundant males were also found. Hibernation occurred in the full grown larval stage within the body of the host. The interesting statement is made that the aphid undoubtedly continues to produce young during the three days that the parasite egg takes to hatch, and probably also until the larva is about half grown, making in the summer about 7 to 8 days during which the parasitized aphid can still produce young. What is probably a secondary parasite was reared and proved to be the Mymarid *Asaphes americana*.

SPAIN.

The introduction of the parasite into Spain was not attempted until quite recently. Director Jaime Nonell Comas, of the Phytopathological Station at Barcelona, reported in 1926 that in June of that year colonies of *Aphelinus mali* were imported from Italy and Uruguay. The initial work of acclimatization was done in the insectary, and later generations were multiplied in the open field in Alella where a collapsible cage was put up. By September the results had far exceeded all expectations.

In the report of the work done by the Stations of Agricultural Phytopathology and Agricultural Entomology in Spain for the year 1927, published in December of that year, is the statement that the acclimatization and distribution of the Aphelinus had proceeded satisfactorily. Incidentally the statement is made that a five-per-cent solution of methylated spirits gave good results experimentally against the woolly aphis. The breeding and distribution seem to have been done mainly at the Barcelona station under the director, Don Jaime Nonell. Colonies were sent mainly to various provinces in the north and east of Spain.

SWITZERLAND.

From Italy there were sent to Gries, near Bozen, Switzerland, some parasitized aphids from which parasites emerged in September, 1923, and on the 10th of October the parasites were clearly established in colonies of the woolly aphis and emerged on the 27th of October. We have seen no report as to whether they successfully passed the winter of 1923-24.

An excellent little paper by Dr. H. Faës, Chief of the Federal Experimental Viticultural Station at Lausanne, deals briefly with the history of the transportation of beneficial parasites from one country to another, and treats especially of *Aphelinus mali*. Originally imported from France in 1922 and later from Italy, it has been reared consecutively in the federal Domain of Pully. He is not yet able to announce definite results, and defers final judgment for some years of different meteorological conditions. He thinks it probable that it may completely destroy the woolly aphis, and feels sure that it will at the least render an important service by reducing the numbers of the pest.

URUGUAY.

In May, 1912, Dr. Roberto Sundberg, Director of the Defensa Agricola of Uruguay, visited Washington, and, speaking of the entomological problems of Uruguay, he mentioned the fact that the woolly aphis was developing into a pest of considerable proportions. Therefore, when in the early summer of 1920 the success of the carriage of *Aphelinus mali* to France had been demonstrated, it was decided to attempt the introduction of the parasite into Uruguay; and in the autumn parasitized woolly aphids were collected in considerable number, in the United States and in December two packages were shipped to Montevideo, the one addressed to Doctor Sundberg and the other to Dr. G. B. Schurman of the Institute of Agronomy in Montevideo. A previous sending to Doctor Sundberg had not been successful.

On the 13th of January, 1921, the packages were received in Uruguay, were opened by Doctor Sundberg and Doctor Schurman and placed in two cages with apple trees heavily infested with woolly aphis. No living parasites were observed at the time. Later, however, abundant material issued, the sexes were distinguished, and very great numbers of adults were found upon the apple trees, and a very great number of aphids were parasitized. Doctor Sundberg wrote, "It is really astonishing in what abundance the Aphelinus is multiplying in our midst."

The winter immediately following (corresponding to our summer in the north) was passed successfully, and a permanent establishment was virtually assured. Soon large colonies were sent out to different sections of Uruguay, and in February, 1925, Doctor Sundberg reported that the parasite had become perfectly established in all sections of the country and that it was perfectly safe to say that there was no infestation of the woolly aphis where the auxiliary was not present.

With great liberality, the Defensa Agricola began early to send colonies of the parasite to other countries. The list furnished me in 1925 shows the following sendings: 1921, to Italy and Argentina; 1922, repeated to the same countries; 1923, to Chile and to Germany; 1924, again to Italy.

The conditions remain the same; the parasite is perfectly established in Uruguay and continues its good work; the woolly aphis seems to be well under control.

THE MOUND-BUILDING ANT, FORMICA EXSECTOIDES F., ASSOCIATED WITH TREE-HOPPERS.

E. A. Andrews,
Johns Hopkins University.

Since this common mound builder of the Eastern States is very active all through the warm months and puts forth great energy in the building of its large earth nests, it is of interest to inquire into the nature of the food that keeps it going and tides it over the winter in a semitorpid state in which the food eaten in summer seems the basis for continued life. Near Baltimore in the special region elsewhere described this ant feeds upon offall and earthworms, etc. to some slight extent; but its chief food is got from other insects; either directly by capture or finding of living or dead beetles, flies, bees, bugs, and especially the larvæ of Lepidoptera, or indirectly by utilization of the honey-dew given forth by insects that suck the sap from trees. The protein food got from insects seems small in amount as compared with the chief diet of honey-dew which is largely carbohydrate.

To obtain this honey-dew the ants make long and difficult as well as dangerous excursions out of the nest over the earth to trees which they ascend and explore out to ends of twigs and branches; but in this region the ants are not found swarming over all trees; wild cherry, oak, and sassafras are here seldom traversed by the ants, but processions of ants pass to and from the nest mound to the bases of large tulip poplar trees, *Liriodendron tulipifera* and the much smaller and younger black locust trees, *Robinia pseudacacia* up and down the trunks of which processions ascend and descend scattering and assembling on many parts of the vast system of branches and twigs. In the tall tulip trees the ants disappear from sight but in smaller trees they are seen tending an abundant scale insect, apparently *Eulecanium tulipiferæ* Cook, as figured by Felt, which, remaining in one spot occasionally opens a dorsal hole from which clear honey-dew drops are taken by the ants all through the summer and on into October when adult and very young scale insects were very abundant. So much excess honey-dew

is voided by these scales that the leaves of underbrush are smeared as with varnish which is sought out and salvaged by the ants, to some extent. The honey-dew collected from these scales on the tulip tree returns to the nests in the ants that are visibly swollen and translucent as they descend the tree and when taken at random from a tree trunk in July those ants going down weighed each 13 milligrams while those going up empty weighed but nine to ten. It is therefore no wonder that some of the largest mounds seem to have flourished through past years upon the honey flow from some large tulip tree, it may be seventy feet in height, although standing thirty-five to even two hundred feet from the mound yet visited by the ants in long processions.

In this region honey-dew from aphids seems a short and negligible source of energy for these ants though elsewhere it may be very important as Pierson states that it was rare that large colonies of aphids attended by this kind of ant were not found near the mounds. The only use of aphids by this ant that we noted was that in May 1926 black aphids were seen attended by ants, eight ants to 30-40 aphids, on shoots of some poplar tree and solitary aphids much smaller than the attendant ant were found underneath the leaves of this poplar tree; also large dark aphids were attended by this ant on vigorous shoots of the black locust, July 23; but later these aphids were deserted by the ants and the aphids did not continue on into September.

Some few ants were also seen to drink liquid directly from the glandular structures on the leaves of young silver poplar shoots May 29, 1927, but this direct vegetable supply of honey-dew was very exceptional.

It is, however, to the young black locust trees that have through some twenty years spread over the old mine dump that the mound ants, advancing through these years into this new source of supply, look for a steady and long season supply of honey-dew presented to them by two sorts of leafhoppers, Membracids; namely the small *Vanduzea arquata* Say and the larger *Thelia bimaculata* Fab. which latter was less abundant in 1927 and 1928 than in 1926.

Thelia is known only upon the black locust and in this region Vanduzea is found only upon the black locust; thus this tree, its two parasites and the ant, form a close association which we emphasize in the present narration.

When the ants first come out of hibernation they seem to find no regular supply of food and content themselves with working to refinish the surface of the mound degraded by winter. After a month or so when the leaves of the locust are but an inch long, it may be May 15th, the ants are seen crowded at the tips of branches as if eating the leaves but it is then that they begin to obtain honey-dew from the newly hatched Vanduzea emerging from the eggs laid last fall in the bark, and aggregating near the bases of the fresh leaves. These larvæ passing through moults become adults in June and gradually more and more adults are commingled with the young in mixed colonies on the twigs, through July, August and September, all the time attended by ants even till October 8th.

Apparently here, as at Ithaca, there are four broods of Vanduzea that maintain the supply of honey-dew for the ants during this long season. The aggregates, or colonies, of Vanduzea are very diverse in make up comprising larvæ of different ages or instars, as well as male and female adults in all proportions and the entire number may be sufficient to attract attention as a dark mass near the bases of leaves or on the leaflets. One colony had thirty females, 10 males and only two larvæ attended by six or seven ants; eight or nine ants may attend twelve adults with eight or nine larvæ, or one ant may attend a single larvæ; there is no fixed relationship of number between the Vanduzea and the ant; but larger clusters generally contain many more larvæ which are in the majority and the ants are generally less abundant than the Vanduzea.

The Vanduzea larvæ are inconspicuous objects adhering closely to the bark of twigs, inactive, but capable of running about to obtain a new spot into which to sink their sucking mouth parts. Such migrations they readily make when stimulated by touch, but when run over by ants they remain inert. The adults with triangular bodies 5 mm. long, 2 wide and 2 deep like the smaller larvæ stand in under the legs of the ant which is 7mm. long and though but 2-3 wide has from its long legs a standing spread of 5 mm.

When roughly touched the adults hop off into space and fly away or else run along the bark, often to the opposite side of the twig. Here again the running of the ant over the adults fails to liberate this hopping-off reflex and the adults as well as

larvæ of all ages stand in place under the actively moving ants. Yet on one occasion in August when all are most active, an ant running along the bark collided violently with a crawling adult with the result that the above reflex cast them both off into the space; suggesting a possible inconvenience to the ant in associating with this tree-hopper!

Whether ants are present or not each Vanduzea larva from time to time rears up and emits a clear drop of honey-dew which falls to earth, or upon leaf, or bark, or else is taken directly by the ant. Several times such drops from both adults and larvæ tested with litmus paper gave areas of 2 mm. in diameter in red, indicating acidity, though the taste is sweet.

The number of drops given off varies much with the individual Vanduzea and with other factors. But little is got by the ants from the adults as compared with the larvæ, and the adults often smear the drop onto their long folded wings. As late as September 18 when the temperature was 20 degrees centigrade, a recently shed larvæ sucking the bark gave off one drop and then no more for ten minutes, though this same larva an hour before had given off drops at the following rates: 46, 60, 54, 240 seconds; all these drops were at once removed from the larva by the attendant ants. One ant may drink from many Vanduzea and several ants may drink from one Vanduzea.

While the Vanduzea is thus a relatively inert, passive member of the association, the other symbiont, the ant is deeply implicated. When larvæ of Vanduzea with ants were carried many miles and placed upon experimental trees the ants continued to attend the larvæ as they migrated to the new sources of sap, remaining with the Vanduzea by day and at night standing stretched out over them only retreating under the twig in heavy rain.

Whenever attending the Vanduzea the ants are much on the qui vive, rushing to attack all intruders or possible sources of disturbance, even odors, jars, contacts, or near presence of moving objects and for some time they run about over adjacent leaves or twigs before settling down again to their stand or slow progress amongst and over the Vanduzeas. Here they spend much time in going over the surfaces of the Vanduzea with antennæ and with palps. The vibration of the antennæ many times a second both over the Vanduzea and over the

bark near by suggests rather a search for, or appreciation of, stimuli received, as of odor, than actual attempts at stimulating the Vanduzea to give forth honey-dew.

Since the time of Linné some ants are known to stimulate the aphids to give forth honey-dew, and Mordwilko found that gentle touches with a needle would stimulate the aphid to give forth 2 to 4 drops quickly. Attempts to thus stimulate Vanduzea were long in vain, but in 1928 success was had with Vanduzea, with Thelia and with certain aphids. It is thus probable that the ant stimulates the Vanduzea and thus modifies the rate of output of honey-dew.

Though the ant makes an exception to its general rule of attack upon insects by leaving the Vanduzea immune, yet when the Vanduzea is dead or even very severely injured it is picked up and carried to the mound, apparently as food.

Ants were seen to attack and destroy the bases of small locust trees though inhabited by colonies of ants and Vanduzeas in symbiotic association; yet here the ants not only cut off their supply of honey-dew, but since there was no evidence that the ants ever transported the Vanduzea to better quarters or that the Vanduzea migrated of themselves down out of such trees, though in the laboratory death of the tree led to some migration of tree hoppers; they also jeopardized the lives of the Vanduzea with resulting loss of egg-laying and future broods of honey-dew producers.

The honey-dew taken from the Vanduzea ultimately benefits the entire commune since each ant returns to the nest and gives up of its collection to ants encountered. The length of time spent by each individual ant in collecting a sufficiency varies very greatly in different colonies and at times of day and season. In the heat of the day marked ants remained with the Vanduzea more than fifteen minutes before descending the tree. But as late as October 2nd, two marked ants remained with fifteen adult Vanduzea for two hours. Running finally very precipitously down the branches and trunks of the trees to the earth the replete ants may do one of several things: search over the earth for droppings of honey-dew, and then return to the tree; or may go straight off from the tree toward the nest; covering such a distance as 31 feet in seven minutes and thus rapidly bringing home honey-dew at midday; frequently, however, the replete ants coming down the tree may

go into holes in the earth at the base of the tree and remain for a few minutes, cleaning themselves and their companions and then either reascend the same tree or go off to the nest. Thus is initiated a flow of ants to and from the food trees along wide but definite paths of travel along which the ants run with speed in the heat but with increasing slowness in the evening coolness. Early in August the flow up and down an inch tree, five feet high, was noted as twenty-two up and twenty down, in seventeen minutes, progressing in unequal squads, three up, three down, in the first two minutes, five up, six down, in the next three minutes, three up, one down, in the following two minutes, then nine up and four down in five minutes, and finally two up, and six down in the last five minutes. On a much larger locust, ants went 59 up to 52 down in five minutes about 7 p. m. September 7th.

Delivered thus from the bases of locust trees ants loaded with honey-dew advance over the earth to the nest, ninety feet in one measured case. The ants going to and from the trees to the nest ran along their paths so that in five minutes we counted eighty-eight going toward the nest and seventy-eight from the nest, in August, or later, in September, at dusk 78 towards and only forty-five from the nest, or later at eight p. m. with increasing cool and darkness, only forty toward and but fourteen from the nest; yet this diminution in flow as day passes into night was not regular and progressive since three minutes after that last record showed 22 toward and 21 outward bound; however with the oncoming of darkness, records were unreliable since the use of searchlight drew the ants aside from the path and thus upset the normal flow along the path. On this same path sometimes but six ants went out at sundown. When the night was warm some few ants went forth and returned at all hours running but slowly; and many remained attending the Venduzea for long periods. Vanduzea in colonies at ends of branches receive more continued attendance from ants while Vanduzea along the line of march may be the more visited by passing ants.

Turning now to the association of these ants with the large tree-hopper, Thelia, we find the same general facts as above described for Vanduzea with some added features arising from the fact that this tree-hopper, as found out by Funkhouser in his elaborate study of its life history, deposites its eggs under

ground in the bark of the base of the tree. With large dorsal hump the quaint adults measuring 13 mm. in length, 10 in total height and 5 in width are much more bulky than the attendant ants which are about half as long. Characteristically they stand long in one spot on the bark (some marked adults did not move from 3:30 to 5:15 p. m., October 8) but readily sidle about the stem or leap off and fly away; but if fallen on the earth upside down find the hump on the back a serious obstacle to recovery.

The larvæ passing through five instars from 2 to 10 mm. herd together like Vanduzeas and may be commingled with them, various instars mingled, but the larger instars are often concealed in crevices of the bark of larger trees. Their presence, as others have noted, is often first revealed by the motions of the attendant ants, since the larvæ are inconspicuous and long remain in the same spot loath to move without strong stimulation. Two larvæ in the fifth stage remained 40 hours unmoved, September 5th and 6th. Under the lens in the direct sun their odd forms, rough surfaces, scintillations of purple, blue and green, with many golden setæ, make them more attractive than the adults. The honey-dew from the third instar was found to be acid, as in Vanduzea.

The period of their activity as purveyors of honey-dew to the ants is a long one and continues late; May 22nd they were found in the second instar at the bases of a small locust tree within the ant-made tented "succursals" illustrated below. May 29th many of these second instars were three feet up the tree attended by ants.

During June larvæ were found spread over the branches, but in July, August and September much more numerous colonies of Thelia larvæ abounded on the stems and branches, sucking sap from near the bases of leaves and also from old wood where cracks in the bark or wound healing offered advantages. On different dates the numbers found varied; apparently there were several broods growing up to scatter somewhat as adults. The young that escape from succursals move upward; in mid August sixty larvæ in first, second and third instars, attended by only one ant, were nine feet above the earth; the youngest must have made their way up in the week since they were hatched below ground. When cornstarch was scattered on larvæ the whole group migrated some 40 mm.

up to a new leaf base. The response of the larvæ to rough touch is like that of the adults; but not being able to fly they fall off to the earth, inactive, for a time; they may then best be gathered up by presenting them with some small object to which they cling.

As in Vanduzea there is no fixed proportion between the numbers of larvæ and of attendant ants. Forty larvæ were attended by twenty-five ants, sixty had only one or two ants; but after August rains that may wash them off one group contained four Thelia, one Vanduzea, and one ant, another two Vanduzea, three Thelia, and one ant. Generally the more larvæ the more ants attend. While all larval stages yield much honey-dew, the adults supply but little, putting drops on the bark or letting the ants drink it directly from the body, and they tend to finally separate from the ants which no longer evince interest in them and then they form the well known clusters of males and females standing faced one way along the twig; thus thirteen adults stood on three inches of branch, only one being female, at a period when adults in copula were observed. While the females are larger and dull brown, the males are striking as presenting a wide yellow band, but in one case a melanic male was black with white band.

With temperatures of 16 C., October 8th, both adults and larvæ were still on some of the locust trees though most of the ants had withdrawn under ground and only on sunny mounds were there active ants that could still obtain honey-dew from these Thelias that thus supplied food up to the end of the ant's season of activity.

The succursals above referred to seem to base upon two potent tendencies of these ants, that to cover up many objects with debris and that to dig holes in the earth. Some ants, especially in the tropics, are known to cover over the insects that yield honey-dew, but Wheeler has described covers, or tents, made of earth or of carton an inch in length made by small ants over coccids and over *Vanduzea arquata* in the northern United States. That *Formica exsectoides* may have such tendency is perhaps indicated by the observation that these ants carried some grains of earth up the trees and deposited them near the Thelia larvæ and that one ant was carrying a large stone two feet up a tree, but the stone was then dropped and no actual covers were made up in the trees. The digging

habit is deeply rooted in this ant, each mound starts as a series of vertical shafts and the excavating work is never brought to an end as long as the ants remain. New mounds may be made near old ones or remote from them by few ants starting new excavations. In one case observed June 30 to July 23 a large number migrated out from an old mound, which, however, still remains populous, and dug many holes forty-five feet from the old mound carrying adults, clusters of eggs and young to the new mound that there arose and continued on successfully in following years, apparently quite without any further connection with the mother mound.

Along the line of migration some groups of idle ants seemed suddenly seized with the furor of digging, 20-30 feet from any mound and 6-8 from any food-tree, soon excavating a small well or succursal one-half inch deep and some five days later a small group scrambled over one another to dig such a hole close to the line of march but some fourteen feet short of the arising mound. In the start the ants kick away the loose surface sand, nervously, then begin work with mandibles, pulling off pellets that are carried a little aside and dropped; others crowding in pull the first ant out of the little cup it is digging, rootlets are tugged at; one would suppose there were buried young sought after by the ants; but gradually fewer ants work; the hole becomes more than an inch deep and in three hours is abandoned and not used. The operation seemed an abortive effort at nest beginning. Scattered over this region amongst weeds and brush are many holes in the earth, one quarter to one inch wide and going down as far as four and a half inches; only occasionally with an ant in them such holes seem to be of no use and may be due to such outburst of nest making abilities, for though looking like wasp's burrows they seem undoubtedly the work of this ant.

In addition to these slight excavations there are real succursals at the bottoms of food trees. A tulip tree 40 feet high and 35 feet from a home mound showed ants ascending and descending as well as going and coming over the surface of the earth from mound to tree; other tulips 100 to 200 feet from mound showed holes in the earth at their bases. At the base of the tree several holes led down into the earth and many ants from the tree went into these holes, but the holes did not connect with the mound though they may branch somewhat

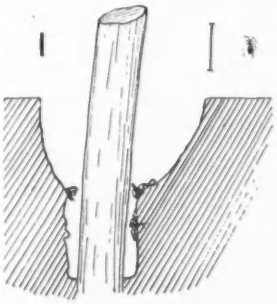
under ground and the ants that enter ultimately run to the mound along the surface of the earth. Attempts to find, by digging, any underground connection between trees and mounds were failures though there are areas where the ground is traversed with tunnels and there are tunnels starting out from the base of the mound.* When these succursal holes at the base of a tulip tree were dug away the ants came down the tree into the large excavation thus made and thence out over the earth to the mound passing back and forth without the aid of the succursal.

The use of succursals was more evident in the case of small locust trees up to 6 inches in diameter. Here again the ants often went down into the holes they had dug at the base of the tree but when the earth was removed the tunnels of the ants were found to have blind ends and not to extend far. The ants soon went back and forth over the cleared area made by the removal of the earth, needing no cover at the base of the tree as a necessary part of collecting honey-dew and carrying it to the mound day after day. Some of the locust trees an inch or so in diameter and six feet high had cavities about their bases such as indicated in Figure 1. Here the pit about the tree was partly blocked by rubbish at a depth of two inches and then continued as a narrower passage two inches deep. In cases in which excavated soil had all been carried away by the ants it seemed possible that the tree swaying in the wind might have made such holes about itself. But many of these holes at the base of the trees had side tunnels, some only an inch long and ending blindly and in these ants were found resting, concealed in general, though from some aspects, a lens revealed them. Such ants within the succursal may stand inactive, it may be seven minutes, before they emerge from the succursal and there may be several ants together or only one solitary ant. In the former case, it was observed that the ants clean one another and apparently interchange food at the mouth. Single ants rest and clean themselves.

Ants that built a large mound in the laboratory when allowed access to a flower pot of earth and sawdust with living locust tree, dug holes at the base and used them as succursals, but

*These observations suggest that these succursals misled McCook into the inference that these ants have underground passageways from mound to feeding trees; but these he actually failed to find. Trans. Am. Ent. Soc., 6 1877.

they also dug at the edges of the pot where vertical and horizontal met. Watching in the open the ants on the tree trunks with succursals, it seemed that some on descending after attending the Thelias went direct to the mound, others searched about on the earth, while some entered the succursal first. Also ants coming from the mound entered the succursal or else went straight up the tree, one even using an inclined straw to cut short the distance over the succursal. Then marking ants with white or with red paint, we observed, after the excitement of the painting, these ants resumed attendance upon the membracids but finally went down the tree to the



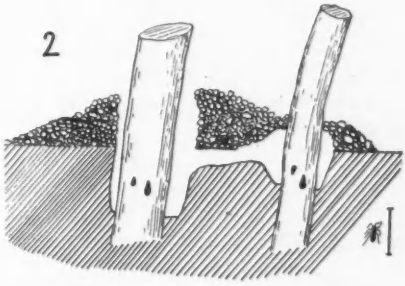


Fig. 1. Succursal dug by *Formica exsectoides* about the base of a young locust tree.
Fig. 2. Succursals of *Formica exsectoides* about the bases of young locust trees. These are connected by a tunnel and protect young *Thelia bimaculata*.

base. Here some entered the succursal and after rest returned again up the tree or emerged on the earth where they either searched about for honey-dew dropped from above or proceeded directly away toward the home mound. Also ants coming from the mound went directly up the tree or else first entered the succursal to remain for a while. There was then opportunity for empty ants from the nest to receive honey-dew from repletes from the tree; but this was not observed.

Among the young locust trees spreading over barren iron sand a most striking fact was the occurrence of small mounds of earth and gravel at the base of many trees on which ants tended membracids. These striking little mounds remained through July and August but later were washed away by rains. As indicated in Figures 2–5, these little mounds are collections of stones, leaves, sticks and earth just as are the mounds used

as nest but each mound is small and has no reference to breeding though it is found to be a temporary branch house within which ants pass some time and also obtain food. These little mounds are essentially roofed-in succursal excavations over which collected material from the neighborhood is piled up so that they have all the architectural elements of the home mound save only the complexities of the internal structure. Figure 2 gives a sectional view of one mound built about two adjacent small locust trees. The earth is excavated about each tree and a tunnel connects both excavations as one cavity, closed in part above by collections of stones, etc. This mound had dimensions of two by three inches and height of from 1 to 1½ inches. The cavity about the smaller tree was nearly closed above but with some space for ant exits while the larger cavity had four definite exits for ants above where the gravel was not in contact with the tree. The heaped up material weighed 2½ ounces or 146.5 grams with a bulk of 100 c.c. Most all was stones, up to 4 by 6 mm. and 5 by 7 mm., many 3 by 4 mm. There was some vegetable matter, bits of dead leaf and sticks, several flat seeds; some few hundred sticks and leaves. Spread out on paper over 35 cm. square, the mass was estimated as 12250 stones with pellets of earth now broken down as sand, bringing the total number of objects piled up by the ants as about 20,000. Ants were found down in these cavities and when the tree was disturbed a dozen, twenty or up to seventy-five rushed out up the stem through the several exits and attacked any new object accessible. Moreover, in all the early summer Thelia larvæ were found on the stems of these trees under ground within the cavities excavated by the ants.

In the above mound, Figure 2, about twelve Thelieas were on the two trees sucking from the bark, head up or down on the bark as suggested by the black triangular spots in the figure. These young were of two sizes, ⅛ and ¼ inch corresponding to stages or instars, three and four of the five given by Funkhouser as occurring during a month of larval life. Other larvæ were several feet up the tree, July 11, and these like those underground were attended by the ants. One ant up the tree seized a fourth instar and carried it inert, lifted up bodily by the back, downwards toward the succursal, but one leg of the larva catching in the bark, the ant pulled hard and finally changed direction, ultimately dropping the larva a foot and a

half to the ground. The pile of stones having been removed, the larval Thelia fell into the succursal, while the ant ran about on the tree as if searching. In capture bottle ants may carry the larval Thelias about as if they were ant young. In another case, a Thelia larva, disturbed in one of the mounded succursals ran up the tree trunk seven inches while an ant, dragged at it, trying to bite it, apparently irrigating it with the acid. The larva put out its abdominal extension and let honey-dew drop several times. The last drop, falling on bark, was licked up by the ant while the larva escaped and ran up the tree. These were the only observations indicating attempts of the ant to restrain or control the Thelias and the small number of Thelias found under ground compared to the larger numbers of ants is not in favor of the view that the ants assemble the Thelias in

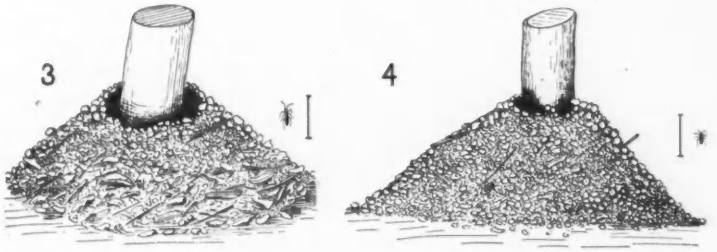


Fig. 3. Succursal of *Formica exsectoides* about base of young locust; composed of leaf-trash as well as of small stones.

Fig. 4. Succursal of *Formica exsectoides* composed of stones and earth the type found on bare ground.

the house they have built, though they do roof over the excavation in the case that there are Thelias within it. Even 17 days after the removal of the material of the mound (Fig. 2) the ants had not reconstructed it though they had kept the succursal free from rubbish and a dozen or more stood active in defense of the open succursal.

These little mounds about food trees were rather uniform over the region of bare soil, but in more wooded areas were but faintly represented by slight heapings up of dead leaves and vegetable matter blocking the entrance to the succursals when Thelias were to be found sucking from the bark a few inches beneath the surface. The conspicuous mounds were made up as in Figure 3, partly of leaves, or, as in Figure 4, almost entirely

of stones, moreover the entrance was either a complete circular one all about the tree or several openings between which the piled up material touched the bark of the tree. In all cases the exits were at the top and not at the base as in a real incubation mound.

These mounded succursals are made in the early part of the season when Thelia larvæ are down in the earth; as time advances, the material becomes compacted by rains and seedlings begin to grow, as in Figure 5, increasing the resemblance to miniature mounds, though they have nothing to do with breeding which is the prime use of the nest mound. It is only in these exceptional regions of bare soil that these tented succursals are such striking objects; elsewhere, in the thicker growths of trees with forest litter, the succursal covers of vegetable matter escape notice and have apparently been overlooked in literature of ants. They were found well kept up as late as July 28, but when roofs were taken off they were not renewed. Though the roofs be finally destroyed by weather, the ants continue to use the succursals even in October with temperatures of 10 C., when some sluggish ants were cleaning themselves and one another in the succursal, while others attended the Vanduzea and yet others were creeping slowly home at 5:50 P. M.

While membracids belong above ground, their presence underground was observed by E. D. Ball in 1915 (4), for he found *Vanduzea vestita* Godg. living exposed to the air upon plants in the Mississippi Valley, but in arid Colorado clustered near to, or several inches under ground on the stems of Amorpha, the lead plant, and of *Campelinchia curvata* Fabr. Ball gives a figure of a stem running down as a root under a stone on a mountain slope in Colorado, with Vanduzea on the stem and the root under ground. However, the earth was absent from about the stem and over the main root where the Vanduzeas stood, so that they were in an air chamber opening up freely to the surface much as in our Figure 2. Such cavities, he says, extended several inches down and occasionally had lateral galleries. That these cavities were really succursals dug out by ants seems certain, but Ball says he did not know whether the excavations "have been made for them by the ants or may have existed previously."

There is thus an association of ants with membracids even in some of the succursals as well as upon the branches where the membracids usually feed. That the ants bring the membracids into the succursals or that they force them to remain there is conjectural. In the case of *Thelia bimaculata* Fabr., that lives only upon the black locust, *Robinia pseudacacia* L., accepting the statements of Funkhouser that the eggs are laid only underground, it may well be that the young find themselves underground and remain sucking there till they gradually migrate up the stem. The arching over of the tent roof made

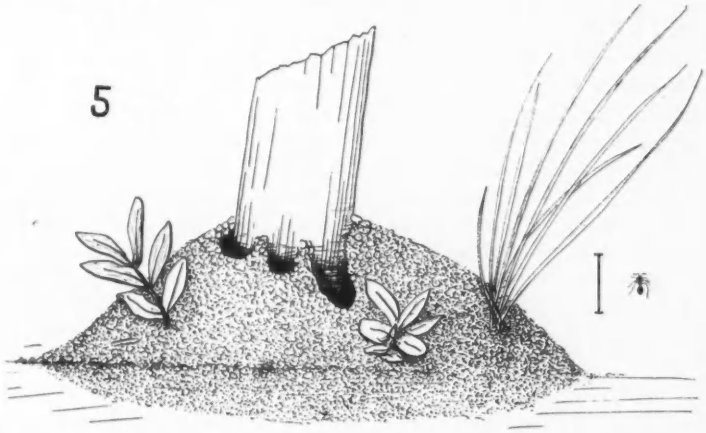


Fig. 5. Succursal in late season, compacted and with vegetation beginning to appear on its surface.

by the ants and their passing back and forth would tend to limit the free upward passage of the young Thelias and the observations made above might indicate that the ants do sometimes restrain the migration of the young. Obviously the young are well protected if they are inside a succursal used by a dozen or more of these ants. Another advantage to the membracid will be the presence of the succursal as a means for the adult getting access to the underground part of the stem for oviposition. Where the forest litter is very loose it may be that the adult Thelia can force its way unaided down several inches to lay just above the roots, as discovered by Funkhouser, but it would be a gain if the Thelias found

openings made by the ants. The adult Thelia with its high punchinello spine and small legs seems ill made to force itself into the earth and in the hard subsoil where the tented succursals were found it seems absolutely necessary that the Thelia should have some hole made for it, as by the swaying of the young tree or by digging of the ants. The old succursals more or less abandoned by the ants in the later season would be most useful for the Thelias to gain access to the underground bark and from this point of view there seems foreshadowed a possible dependence of the Thelia upon ants.

That ants get honey-dew from membracids is well known since Belt (7) in 1874 pointed out that in the tropics membracids and coccids largely take the place of the aphids of Europe in furnishing honey-dew to ants, and Green (8) in 1900 in Ceylon saw the extrusion by larval Centrotus of a long three-jointed caudal tube with crimson tip and white base "immediately upon application by the attendant ant," and Lamborn (9) in 1913 found the membracid, *Leptocantrus altifrons* Walker in Africa "invariably attended by ants" that were extremely partial to the fluid extruding from the pink caudal whip, and Hinston (15) revealed such wonderful associations in India. Even in the north, ants and membracids form associations as shown by Rice (10) in 1893 and Branch (11) in 1913. The former found the membracid *Entylia sinuata* on sunflower leaves, in Pennsylvania, guarded by two species of ants, one or more ants to each colony, preferring these to aphids and herding them together and supervising the process of ecdysis; and the latter in Kansas found the same membracid attended by numerous species of ants supposedly attending to their wants and being repaid by honey-dew.

The association of membracids and ants raises various questions; in attending does the ant do more than protect the membracid or does it so stimulate it as to vary the amount or frequency of honey-dew given off; on the other hand does the presence of the ants make any difference to the membracid other than the protection that may exist? Funkhouser was able to rear the membracids without ants, and found no evidence that the ants herded or assembled the membracids they associated with. In Baltimore these Thelias are found on trees in some regions far away from any ant mounds. It is commonly assumed that the ant stimulates the membracid

by strokes with its antennæ, thus inducing the membracid to let down honey-dew when so stimulated. The membracid seems to show no general response to the presence of the ants. We observed that adult Thelias overrun by these ants do not fly away as they often do if disturbed, but remain inactive when stroked and bumped against by the ants while the young in all instars remained immobile when ants ran over them and stroked them. On the other hand, the ants are excited by the presence of the young or the adult Thelias and remain with them and on the offensive much as with their own young, and ever ready to attack all that come near. The ants draw a sharp line between dead and living Thelias, carrying the former intact or mutilated into their mounds, but leaving the latter quite unharmed.

Thelia larvæ when not attended by ants squirted the honey-dew 1½ inches clear from the vertical trunk of tree they stood on; but when the ants were present the drops came slowly forth and were taken into the mouth of the ant or ants from the tip of the larval Thelia which had extended its telescoped abdomen, revealing a white tube with black tip crowned with unequal row of colored bristles, which forms a basket in which the small drop may linger till all drunk up by the ants. In a few seconds as many as six drops may thus flow out and this flow may be repeated several times in five minutes as seen in daylight, or by flashlight at 7:30 p. m. as late as September.

To test whether ants actually stimulate Thelia to modify the output of honey-dew, the following experiment was made: Larval Thelias standing at least two days on a large trunk were first observed when attended by ants and then when ants were kept away by a barrier of vaseline, all precipitous intruders being thrown out. One Thelia gave off drops at the following intervals when attended by ants: 1, 6½, 3½, 4, 1, 10, 14, 0, 5, 1, 3, 1, 2, 4, 1, 2 minutes and at the following intervals when left unattended: 15, 4, 11, 19, 7, 12½, 6½, 6, 17½ minutes. The intervals were thus generally shorter when ants were present. In the former case there were seventeen emissions in the hour, with intervals ranging from 0 to 14 minutes and an average of 3. In the latter case there were but ten emissions during an hour and a half at intervals ranging from 19 to four minutes and an average of nearly ten. When the ants took off the honey-dew the number of drops was not determined but

may have been twenty-four to seventy-five in one hour, but when the Thelia cast off its drops they were counted as more than 41 during the hour and a half; thus there was no evidence of any increase of number of drops in connection with the presence of ants. Since the observation with ants present was from 11:30 to 12:29 a. m. and that without ants from 3:00 to 4:38 p. m. some difference in rate of honey-discharge might have arisen from differences in time of day; however, two days later, September 9th, another Thelia larva was seen to give off drops at the like brief intervals when attended by ants even as late as 4:19 to 4:28 p. m. We may then infer that the rate of honey-dew discharge is hastened by the presence of these ants, the more so as some Thelia, when not attended by ants, stood without giving off drops for more than an hour.

With no ants the honey-dew accumulates till forced out by violent effort of the organs of the Thelia; but with ants present a more frequent delivery is induced without forced discharge. There may thus be a mutual advantage in this association, the Thelia gaining some economy of effort while the ant gains food materials.

While it is assumed the ant stimulates the Thelia by stroking it with antennæ this was not proved. Ants approaching Thelias may vibrate their palps as if gathering sensory impressions and the movements of the antennæ suggest picking up of impressions rather than attempts to impart stimulus to the Thelias; however, since we have induced Thelias to give forth drops when touched, the touch of the ants doubtless stimulates the Thelia to partial discharge.

As emphasized by Kornhouser, ants frequently stand at the head end of Thelias and we see the ants stand for long with mouth close to various parts of the abdomen, not always at the tip whence may come honey-dew and thus something in the surface of the Thelia seems to hold the ant pointed at the body of the Thelia. One stood at the head and one at the other end for nine minutes as if held by attraction, getting no honey-dew. Ants being content to stand long close to parts of the Thelia from which no honey-dew emerges suggests that the ant may be influenced by some emanation of the body. When the Thelia move away along the bark the ant may spend much time cleaning off the bark where the Thelia had stood an hour or more. This cleaning of the bark might refer to collection of

honey-dew or to collections of Thelia skin exudates. Possibly the intense interest shown by ants in the process of ecdysis or skin shedding of Thelia nymphs may be due to exudates of the Thelia skin. Thus July 16, when forty nymphs were attended by 25 ants near the crotch of a tree and very many ants were constantly passing up and down close by, it was observed that many turned aside a moment from the path to stand near a Thelia shedding into a very late instar, but soon passed on only temporarily diverted by some influence from the larva in ecdysis. But some ants remained with the young that emerged light colored and soft. As it emerged an ant went all over it with its palps, especially at the tail end as it left the larval skin. The ants near were much exicited; jumping to attack. The ants licked out the inside of the cast skin and left it to flutter in the wind, while the freshly emerged Thelia moved through 180 degrees and settled down to bore into the bark while the ants all went away as if no longer attracted to it. This special interest of the ant in the ecdysis and especially in the inside of the cast skin might be due to accumulations of skin exudates left within the case skin, but unlikely due to honey-dew within. Such interest of ants in the shedding process was observed by Miss Branch who stated that *Entylia sinuata* was dependent upon ant care for successful shedding. The association of this ant with membracids is a form of trophobiosis that, we suggest, may base upon a mutual give and take, the supposed secretions of the membracid may stimulate the ant to act toward it somewhat as toward its own young, which as Wheeler has shown in some species yields to the adult in the remarkable process of trophallaxis (14) a return for the care given it.

In the Ithaca region Funkhouser found Thelias attended by *Formica obscuriventris* Mayr, *Camponotus pennsylvanicus* De Geer, *Crematogaster lineatus* Say and *Prenolepis imparis* Say as well as by *Formica exsectoides* F.; but in the region we are now considering this last ant was seen to have competition from only a few small ants; however, the ants getting honey-dew from these membracids do not have undisputed monopoly in this region since several sorts of sugar flies frequent the trees to feed on the honey-dew and come into close association with the members of the locust—membracid—ant symbiosis. While five sorts of flies were observed chiefly two were much in evidence, identified by Professor J. M. Aldrich as *Rivellia*

quadrifasciata Macquart and *Callopistromyia annulipes* Macquart. The former is black, smaller than the ant, and holds its wings horizontally extended showing conspicuous black opaque bands alternating with clear. They often go about in twos. They run, fly and jump about nimbly near the clusters of Vanduzeas and Thelias, apparently having good use of their eyes, retiring when an ant comes even an inch away, while the ant seems unaware of their presence, till almost in contact, but though the ant may rush at these flies they merely go a little to one side on same or other twig and await the opportunity to return, but they may go backward when the ant approaches. They run about nervously and sneak up when no ant is present; in form of body and quick nervous action they are somewhat ant-like. With quick, jerky motions they approach the small Thelia and actually drum on the rear body with their front legs, seemingly striking the larva more rapidly than the ants vibrate their antennæ and then with stout hairy proboscis lick off the honey-dew that the Thelia emits and then sit near by on leaves or twigs to later repeat the operation. These flies were seen earliest in the season, May 19, 1927, at Homewood when the locust leaves were four inches long and as yet no ants nor honey-dew were observable. May 30 the ants there were driving these flies away from the Vanduzeas placed on the locust trees. Later in the summer these flies frequented trees with Vanduzeas and Thelias in various localities. In early September the flies were examining top and bottom of leaves of locust, near a group of some fifty Vanduzeas, chiefly adults with 16 ants on a locust branch 6 feet above ground. They were also seen on the earth as if searching for dropped honey-dew near the base of trees. Even as late as October 2 these flies were near groups of Vanduzeas.

The second common fly, *Callopistromyia annulipes* was observed about the ant-vanduzea-thelia groups on the locust from late May to early October. This fly is much smaller than the house fly but grey with stout abdomen suddenly tapered posteriorly and with wings finely peppered and so held up transversely when walking about that the two wings seem one orbicula sail across the body, a spot on each wing adjoining its fellow to make one central bull's eye in the rounded sail. This fly seems ever searching for honey-dew which it may lick off from the leaf or bark. The fly walks about near the posterior

ends of Thelias and seems to brush against them without making any movement of the legs to stimulate them. In fact its food seems to be merely the drops that are cast off onto bark, etc. and not taken by the ants. The fly with its red eyes seems to see the ant one-fourth of an inch away and quickly flies off or else runs along the branch and when followed by man may dodge around to opposite face of the tree like a membracid. However, the fly is ever returning to the same colony of membracids, flying but a few inches and soon going directly back again, if no ants are on hand. When the ant approaches the fly quickly leaves whatever it is eating. When eating the wings of the fly are folded down horizontally over the abdomen, and seem, then, rather truncated.

A third kind of fly has the same ability to quickly return an inch or two when driven off from Vanduzea by the approach of ants. This, like Rivellia, actually drums five or six times a second, or faster, with its black front legs palpating the Vanduzea adult and larvæ, but with no observed result. Found in September, this fly has big head, reddish eyes, flat empty abdomen, clear wings longer than abdomen, carried folded horizontally over abdomen, and is about the size of adult vanduzea female but less thick. A fourth kind of fly apparently in competition with the ants was found recently emerged on the earth as well as perfectly developed in early September. The black metallic body supports wings held down on sides of abdomen with white cross band near the tip; though coming near the Vanduzeas it was not seen to get honey-dew with its large proboscis.

SUMMARY.

1. *Formica exsectoides* F. gets food from living and dead insects and from honey-dew that in the region studied near Baltimore is excreted not only by aphids but by coccids and by membracids.

2. In this region this ant forms food getting associations with *Eulecanium tulipiferum* Cook on *Liriodendron tulipifera* and with *Vanduzea aquata* Say and *Thelia bimaculata* Fab. on *Robinia pseudacacia* L.

3. Vanduzea and Thelia supply honey-dew to the ants chiefly when young, the former with the opening of leaves in

May on through successive broods into October and the latter from late May into October.

4. When no honey-dew is got in March and in November some ants of a colony still labor at the mound, repairing it on emerging from hibernation and improving the roof as last effort in autumn.

5. The membracids are not stimulated by the ants to move about but seem remarkably inert to their presence.

6. Membracids injured or dead are carried off by ants as food.

7. The membracids make no exertion to gain attentions of the ants, in fact may live where no ants attend, but the ants associating with membracids must make long and perilous journeys exposed outside the mound on earth and trees.

8. Ants attend the membracids day and night, individuals taking turns as others fill and return to the mound.

9. When ants are not in attendance the membracids cast off the honey-dew with force, but influenced by the ants, it is discharged with less effort, the culmination of the entire sequence being omitted.

10. The ant explores the surface of the membracids with antennæ and palps as if gaining chemical stimuli rather than stimulating the membracids, yet observations indicate that the rate of flow of honey-dew from a Thelia nymph is increased in rapidity when ants are attending; attempts to artificially stimulate the Thelias and Vanduzeas to give out honey-dew by rapid gentle strokes were successful.

11. It is suggested that the primary influence of membracid upon the ant is through some sort of skin exudation.

12. Succursals made by these ants at bases of small trees when used by Thelias are roofed over by the ants as tents that protect and to some extent limit the freedom of the young Thelias for a time.

13. The construction of these tented succursals for temporary association of ant and Thelia young involves large expenditures of energy in the collection of materials.

14. The honey-dew secreted by these membracids gives acid reactions.

15. In the association of ant and membracid, the former gains a chief food supply; the latter gains protection, and relief

from greater effort. Thelia also gains from the ants advantages of succursal in which to lay eggs underground.

16. While the ants attempt to maintain a monopoly of this honey-dew, there are several sorts of sugar flies associated with the ants and membracids.

17. Some of these flies, as *Callopistromyia annulipes* Macquart merely lick up the honey-dew that has fallen and not been collected by the ants but others, as *Rivellia quadrifasciata* Macquart, drum very rapidly with front legs before taking off honey-dew from the Thelia larvæ.

18. The flies avoid the attendant ants that are keen to drive off the flies.

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THE BROOKLYN AND NEW YORK ENTOMOLOGICAL SOCIETIES, PAST AND PRESENT.

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An association of twenty-eight years with the Brooklyn Entomological Society and nearly as long with the New York Entomological Society may seem sufficient to establish ones rank to seniority and yet in the light of preceding events, this time really represents only the second chapter of entomological organization in the Metropolis of America. Of the leaders, the workers and the fighters of the first chapter, it has been my privilege to know personally only a few. When I joined the Brooklyn Entomological Society in 1900, most of them had passed away or were comparatively inactive. For the historical part of my report, consequently, I must rely in the main on what has been recorded by older members, principally by Charles W. Leng, the historian of both Societies.

Our earliest local developments among insect collectors are related by E. L. Graef in a paper on "Some Early Brooklyn Entomologists" published in the Bulletin Vol. 9, No. 3. He and two schoolfellows, Frederick Tepper and Augustus Radclyffe Grote began the making of collections in 1854. Not knowing anything about cyanide bottles and preservatives and with no literature excepting a copy of Emmons "Insects of New York State" contained in the small library of the Graham Institute, predecessor of the Brooklyn Institute of Arts and Sciences, these lads nevertheless struggled along persistently, eager for information and meeting in turn John Ackhurst, Stephen H. Calverly, Herman Strecker, J. A. Lintner, John G. Morris, W. V. Andrews and Henry Edwards, all men recognized then or later for their work in entomology.

The outstanding event in the entomological career of Mr. Graef was his meeting in 1870 of Prof. Franz G. Schaupp, justly called the father of the Brooklyn Entomological Society. Quoting the words of Graef "He was of middle age, of very large proportions, weighing perhaps 250 pounds, with a massive head crowned with curly hair, well tinged with gray. The hat which he wore would fall around the ears of any person I have

ever met. It measured No. 8. He was pleasant, cordial and overflowing with good nature and humor. We soon became greatly interested in each other and in insects. Of course, we had to partake of a number of beers and he insisted on my accompanying him the next day to what was then known as the Eastern District, which place, he stated, fairly swarmed with entomologists, some in embryo and all of whom he desired should know me. So the next day we sallied forth and I was duly introduced to everybody in the neighborhood who had a collection, even if it were only in a saloon where the proprietor had a framed case of "flies" hung behind the bar. As a sine qua non we had a complement of beers and I may be pardoned if I cannot distinctly recollect all the distinguished entomologists whose acquaintance I made on that memorable occasion. So much enthusiasm was created, however, that Prof. Schaupp and I suggested that we ought to meet regularly and form some sort of an association. Accordingly a meeting was called at Schaupp's rooms, on the top floor over Schaeffer's saloon at 9 Broadway, Brooklyn. This was well attended and resulted in the formation of the Brooklyn Entomological Society. Schaupp was the first President and I the first Treasurer."

Presumably after this informal organization, meetings were continued, but whether at regular or irregular intervals there are no minutes to tell. Most likely the meetings at first were more in the nature of social gatherings at which refreshments, especially liquid, played an important part. From Leng's "Memories of Fifty Years Ago" in the Bulletin Vol. 18 No. 1 we learn that when as a boy of 16 he joined the Brooklyn Entomological Society in 1875 or 1876 its prominent members were Graef, Tepper, Fuchs, Luetgens and Schaupp, the latter the most prominent of all. Leng's accounts of Schaupp and other pioneers are delightful and his sketches of the proceedings at the meetings most amusing. It is hard to resist the temptation to quote him in full.

An era of unrivalled activity and enthusiasm for the Brooklyn Entomological Society set in with the publication of the Bulletin, beginning in May 1878 and appearing monthly at the subscription rate of 50 cents per annum. These rates were increased to 60 cents and later to $1.00. The volumes running from 100 to 150 pages. The Bulletin was managed by a publication committee of five of which Schaupp was the

chairman, as well as the leading spirit as in all matters concerning the Society. His directing influence is unmistakable in the policy and contents of the publication. There are, useful hints for practical collecting, notes on breeding insects, new discoveries and descriptions, synoptic tables of N. A. Coleoptera and Lepidoptera, lists for exchanges; in fact good reading matter for student and layman alike. The Bulletin at once became the popular medium for publishing observations and studies not only by local members but by outstanding entomologists throughout the country as well. A list of contributors to the first volume contains the names, alphabetically arranged, of Dury, Fuchs, Gissler, Graef, Grote, Horn, Hoyt, Hulst, Koebele, Le Conte, Schaupp, Saltzwedel, Schmelter, Strecker, Tepper and Wilson. Schaupp topped the list with twenty papers. Later authors include Blanchard, Hy. Edwards, Meyer, Nostrand, Webster, Bailey, French, Julich, Knauss, John B. Smith, Ulke, Ricksecker, Riley, Holland, E. A. Schwarz, Casey, Cramer, Doll, Leng, Reinecke, Roberts and Willeston, the latter introducing for the first time the subject of Diptera in Volume 7; all previous papers having been devoted exclusively to Coleoptera and Lepidoptera.

The early volumes, we are told, were edited at the meetings of the Society in Schaupp's room and generally under heated discussions, to be continued after adjournment downstairs in Schaeffer's saloon. The Society outgrowing its quarters, meeting places were changed to Wright's Business College and to the Polytechnic Institute. Schaupp's climax of entomological work was attained with the publication of his synoptic treatise of the Cicindellidæ in the Bulletin Vol. 6, November 1883. It contains 81 pages of text, beautifully illustrated with one black and white and four colored plates. Soon after he departed for Texas, a misfortune for the Society and, as it turned out, as well as for himself. Separated from his many friends and co-workers and living in comparative loneliness and poverty he died in 1904.

After Schaupp's departure, John B. Smith, who as a young man of 23 had joined the Society in 1881, took up the reins and we may add, laid the foundation for his subsequent so prominent career. Appended to Vol. 7 of the Bulletin, we find a "Certificate of Incorporation" dated January 13, 1885 and a list of 32 original members, including the following not mentioned before: Angell, Beutenmuller, Duering, Elliot, Frank,

Gade, Linell, Luetgens, Neumoegen, Pearsall, Schenk, Waters and Weeks. The volume concludes with the "Notice to Readers"—"With this number the Bulletin of the Brooklyn Entomological Society ceases to exist. The unanimous expression of the desirability of a union of Entomological Journals into one paper which might call to it the support of all those interested in Entomology, led to negotiations between the representatives of the Bulletin and Papilio resulting in an arrangement for the issuing of a new publication, for which the name "Entomologica Americana" has been decided upon. It will be edited by Mr. John B. Smith, and the subscription price will be $2.00 per annum."

Averaging 240 pages per volume, Entomologica Americana was published regularly in monthly numbers beginning April 1885 and ending with Volume 6, December 1890. Among the authors not previously cited are Ashmead, Cook, Davis, Fernald, Henshaw, Howard, Kellicott, Osborn, Wenzel, Bergroth, Chittenden, Fletcher, Schaus, Skinner, Slosson, Van Duzee, Wickham, and Zabriskie. Meanwhile the meetings of the Society were held at the Brooklyn Institute on Washington Street, where its collections and Library also were housed. Attendance at the monthly sessions was 20 to 30 and even 50 to 70 on some occasions. Altogether the Society was in a most flourishing condition when on September 13, 1890 a fire in the Institute building not only deprived it of headquarters, but more or less damaged its property. Added to this came the resignation of John B. Smith as editor in December. The bottom dropped out. The Society went into hibernation not to awaken until ten years later.

With this all too brief outline of the first chapter of the Brooklyn Entomological Society we cross the East River to see what the entomologists have been doing in New York City. On October 3, 1880 we find at the home of B. Neumoegen, 76 West 47 Street A. R. Grote, E. L. Graef, A. Koebele and Hy. Edwards assembled to form an association to be known as the N. Y. Entomological Club. This duly accomplished, the following officers were elected: President, Augustus R. Grote; Treasurer, B. Neumogen; Secretary, Hy Edwards. In the minutes for the first annual meeting held at Mr. Edwards' house on December 11, 1881, we read that ten numbers of the official organ of the Club "Papilio" devoted exclusively to Lepidoptera had been published and that 127 members consisting of 19

active, 17 honorary and 91 corresponding members had been enrolled. This looks like good progress, but turning to the treasurer's report we find charged to income from subscriptions and other payments $194.46 and to disbursements for printing $415.73, leaving a deficit of $221.27. This looks not so good. In another entry a motion is passed empowering the secretary to alter and modify Mr. Hulst's letter of rejoinder to Mr. Grote, so as to omit all personalities and that Mr. Hy Edwards be requested to publish in the same number all the evidence in his possession referring to the priority of names of Catocalæ now in dispute between Messrs. Strecker and Grote. This indicates dissension and asperity, a spirit not confined to the Club but rampant generally at that time.

And on the other hand, not before or since, has there been so much rivalry and competition among Entomologists to excel in the possession of large, comprehensive collections. Many bitter combats, mostly, but not always, fair took place. With some, the acquisition of great collections became an obsession. They would rather collect than eat. Now that the battles are over and the warriors at rest, it is a satisfaction to contemplate that the spoils of war have not been wasted. The most prominent of the collections are housed in the Museums of New York and Brooklyn or elsewhere, accessible to investigators at all times. A little of this spirit of competition and combat, leaving out personalities, injected into our present placid and regulated affairs might not be amiss.

Meetings of the N. Y. Entomological Club called for October and December, 1882 show the significant entries "no attendance." Papilio ceased with Volume 4, Nov. 1884. To lepidopterists it has been and still is a most valuable publication. Volumes 2 and 3 are exhausted. Volumes 1 and 4 are still available through the Brooklyn Entomological Society.

The next nine or ten years are shrouded in mystery. Not until 1891 we learn from a paper by Chas. W. Leng in the Journal Vol. 26 were meetings held again. On June 29, 1892, the N. Y. Entomological Society was organized with Chas. Palm as temporary chairman and Dietz, Beyer, Tunison, Schaeffer, Beutenmuller, Rabe, Neumoegen and Mrs. Annie Trumbull Slosson as members. In September, Ottolengui, Angell, Havell, Meitzen, Seibolt, Bradford and Julich joined the Society. Thereafter meetings were held regularly at the

homes of Palm, Neumoegen, Mrs. Slosson and sometimes at the German American school on East 53 Street until finally, through Mrs. Slosson's intercession with the late Morris K. Jessup, headquarters were established at the American Museum of Natural History under whose conspicuous auspices the Society has met ever since. The incorporation of the Society was effected June 7, 1893. Previous to that the Journal was started by subscription with Mrs. Slosson the largest contributor. Part of the expenses of printing were defrayed from the proceeds of auction sales of insects, Mrs. Slosson again donating most liberally from her collection. These auction sales afforded Mrs. Slosson much amusement. "I should like to attend one now. The movies are nothing compared to them," she remarks in a paper of reminiscences in the Journal Vol. 26. Regarding her attendance at one of the early meetings at Mr. Palm's house, she says, "I shall never forget the sensation produced by my unexpected entrance into that scientific meeting. Through the smoke of pipes and over mugs of some beverage which foamed in the gaslight in a sudsy sort of way I saw startled and embarrassed faces. 'A woman, and finding us like this!' After seating me in the most comfortable chair, good Mr. Palm hastened away to order coffee as more appropriate and fitting drink for a feminine throat. I was not at all shocked at this orgie, for I had five brothers and spent much of my time in a tobacco-smoky atmosphere. After that I attended the meetings quite regularly and came to know very pleasantly most of the members."

Following its incorporation the Society continued successfully for about ten years, meeting twice monthly. Beutenmuller was editor of the Journal, which was published regularly. The average attendance was about eight members with rarely a meeting lacking a quorum. During this period, Joutel, Shoemaker, Love, Lagai, Davis, Barber, Wunder, Camman, Weeks, Comstock, Watson, Green, Leng, Graef, Southwick, Sherman , Engelhardt and Harris became members. The Society also affiliated with the N. Y. Academy of Sciences, whereby the members receive the weekly "Bulletin" announcements of meetings. Social gatherings after the meetings adjourned became also an important feature. Prof. Wheeler who became a member in 1903, and Dr. Lutz who joined soon thereafter by their active participation and versatility added

much to the interest and importance of the meetings. The attendance grew rapidly, many new members were enrolled and a remarkably good feeling among all was the result. The Society's affairs have prospered ever since.

The time limit of my report does not permit me to mention by name all the good members and friends whose service and loyalty have crowned the Society with success. However I must refer to some of the officers, for few Societies have been so fortunate in the selection of men—faithful and untiring in their labor of love. As Presidents served successively: Angell, Beutenmuller, Zabriskie, Palm, Love, Groth, Roberts, Leng, Osburn, Barber, Woodruff, Sherman, Lutz, and our present honored incumbent Henry Bird. As Treasurers: Groth, Joutel, and Davis. As Secretaries: Joutel, Barber and Leng. That in 35 years only three men have served as Secretary and the same number as Treasurer, is exceptional. The maxim here applies—when you have a good man, keep him in office—and that has been done.

Mr. Leng has been Secretary for the past twenty years. His minutes are models of precision and composition. Often I have been surprised at my own eloquence when reading his account of my talk in the minutes.

Mr. Davis has steered the financial affairs of the Society for twenty-five years and there has been rough sailing at times. How he weathered the storms he does not tell. He doesn't have to. We know. Now his ship has arrived in a safe harbor. Our beloved friend and fellow member, the late L. B. Woodruff, in his will bequeathed to the N. Y. Entomological Society the sum of ten thousand dollars to be applied as an endowment to the publication fund. To him we owe a vote of undying gratitude and thanks. The interest of this endowment added to the income from well above one hundred members and about three hundred subscribers to the Journal, assures to the N. Y. Entomological Society a future of growing influence "in the advancement of entomology in all its branches."

For the last chapter we retrace our steps to 1900 and after recrossing the East River, find that the Brooklyn Entomological Society has awakened from its hibernation and that a meeting has been called by George Frank, manager of the American Entomological Co., at his office and residence on DeKalb Avenue. About thirty people, old timers and newcomers

assembled. I was one of the newcomers. Among those present, I remember Smith, Graef, Pearsall, Weeks, Doll, Call and Love. The death on that day of Geo. D. Hulst, a charter member, was announced. When after adjournment we partook of the liberally provided liquid and solid refreshments in the basement, I passed muster in the proverbial qualifications expected of an entomologist, his ability to drink beer. These social diversions after adjournment, always have been a special attraction at the Brooklyn meetings. I have yet to meet the member who for reasons of his calling or creed objected to these proceedings. They were always conducted within reasonable limits of enjoyment.

The first publication by the Society after re-organization was the Glossary, an Explanation of Terms used in Entomology, by John B. Smith. It was issued in 1906, cloth bound, 154 pages, three plates on stuctures and one on colors. Dr. J. W. Folsom, now at the Delta Laboratory, Tallulah, La., contributed substantially to this publication by sending in over 2000 cards of terms collected by himself and his assistants while at Urbana, Ill. The book, 3,000 copies, was financed from the treasury and by subscriptions from members. It was received so favorably that in less than two years all subscriptions had been repaid and it has been a source of income to the Society ever since. A reprint of 1,000 copies in 1920 has again become nearly exhausted. A revised and up-to-date edition is now under consideration.

The re-publication of the Society's official organ, the Bulletin, was not attempted until a removal to the present meeting place at the Brooklyn Museum of Arts and Sciences on Eastern Parkway had been effected. The Bulletin, New Series, appeared again in October 1912, edited by R. P. Dow, whose essays on ancient entomology afforded frequent entertainment at both Societies. When he left for California in 1919, J. R. de la Torre-Bueno became and still is Editor. Steadily increasing support and a list of subscribers, exceeding 300 have made the Bulletin, now in its 23d volume, about self-sustaining. Meanwhile it has more than doubled its contents.

Entomologica Americana, the successor to the Bulletin and Papilio in 1885, after a lapse of 36 years, also was revived again in 1926, thanks to the generosity of Wm. T. Nichols, Jr., one of our honorary members. Mr. Nichols' untimely death,

early this year, has meant a severe loss to the Society. This publication is issued quarterly, 50–60 pages to the number or 200–240 pages to the volume at the rate of $4.00 per annum. It is intended for longer papers—monographs, synopsis of smaller groups, biological studies, morphology, embryology and revisions too long for regular journals and yet too short for a book. For such a journal there has been a long-felt need. Volumes 7 and 8 have been completed. Volume 9, No. 3, is now in press. Our present aim is to get 200 subscribers of which 125 have been booked.

Compared with the N. Y. Society, the Brooklyn Society appears to be forging ahead with its publications. Its annual expenses for printing are now near $3,000, which has been covered by subscriptions and income from other sources, leaving a safe balance in the treasury. On the other hand, we have not been as successful in the enrollment of members, the list of active members having remained nearly stationary, around 50 for thirty years. Relations between the two Societies are most cordial, many members belonging to both.

As officers for the Brooklyn Society are serving since 1920:

President.....WM. T. DAVIS
Secretary.....ERNEST L. BELL
Treasurer.....GEORGE P. ENGELHARDT
Editor since 1919.....J. R. DE LA TORRE-BUENO

Teamwork between these officials has been splendid, all doing their very best for the Society.

In the present age of specialization friction among members, formerly so rampant, has disappeared almost entirely. The meetings, informal as always, nevertheless are full of zest and interest. After adjournment at 10 or latest, 11:00 P. M., everybody goes home. Gentle admonitions on part of my family, implied in the question "is this going to be a late session" have ceased long ago. What we miss these days are the get-together times at annual dinners and on field meetings which Newark, Philadelphia and even Washington used to join.

When I meet entomologists on my travels, I am always sure to be received as a friend and in a spirit which lets one feel that we all belong to one big fraternity. In this spirit I close my report with the assurance to one and all that a hearty welcome always awaits you at the meetings of the Brooklyn and New York Entomological Societies.

THE DETECTION AND ESTIMATION OF INSECT CHITIN; AND THE IRRELATION OF "CHITINIZATION" TO HARDNESS AND PIGMENTATION OF THE CUTICULA OF THE AMERICAN COCKROACH, PERIPLANETA AMERICANA L.

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The cuticula and intima of insects have long been known to contain an organic compound remarkable for its insolubility in solutions of potassium hydroxide or sodium hydroxide of any concentration. Through this property it was discovered[1] in the elytra of May beetles by Odier (36) in 1823 and was named chitine (spelled chitin in German and English), by him from χιτών, a Greek garment. This substance is well known by name to American entomologists who frequently use the term "chitinous" or "chitinized" in morphological or taxonomic descriptions, but its properties and distribution in insects are still so poorly understood by them that these terms are often misapplied.

The purpose of this paper is to describe methods which have been improved by the writer for the detection and estimation of chitin in insects and to present the results of these methods as applied to the cuticula and intima of the American cockroach and other insects. These results, together with facts from the extensive foreign literature on chitin, will be discussed from the point of view of the entomologist who wants to know what chitin is, where it occurs in insects, and what the relations may be, if any, between pigmentation and hardness and "chitinization" of cuticula. Statements concerning chitin in our entomological text-books which are contrary to fact will be pointed out and corrected.

[1]Strictly speaking, it was Bracconot (7) who discovered chitin in 1811. By treating mushrooms with alkali he obtained an insoluble residue containing nitrogen which he called fungine. He said of it (p. 267), "Cette substance de quelques champignons qu'elle provienne, séparéé de tout corps étranger par l'eau bouillante aiguiséé d'un peu d'alcali, est, plus ou moins blanche, molasse, fade, insipide. . ." But it was not until the end of the century that fungine was proved to be identical with Odier's chitine.

THE PROPERTIES OF CHITIN.

Chitin is a colorless, nitrogenous polysaccharide[2]. Its molecule is composed of an unknown number of acetylglucosamine[3] residues, linked through nitrogen, according to Karrer and Smirnoff (21). By X-ray analysis Gonell (15) proved that chitin is microcrystalline and calculated that the elementary body or crystallite, which may or may not be the same as the chemical molecule, is composed of 18 acetylglucosamine residues. The most probable empirical formula, $(C_{32}H_{54}N_4O_{21})x$, is that of Brach (6).

Chitin is insoluble in water, alcohol, ether, and dilute acids, and in dilute or concentrated alkalies. It is dissolved with or without decomposition by concentrated mineral acids and, according to Schulze and Kunike (44, p. 558), by water-free formic acid. Von Weimarn (51) finds that chitin goes into colloidal solution in solutions of salts, particularly lithium thiocyanate, capable of strong hydration.

Chitin is hydrolyzed by concentrated mineral acids with the formation of a glucosamine salt or chitose, a sugar, and fatty acids, chiefly acetic. It is hydrolyzed by concentrated solutions of potassium hydroxide or sodium hydroxide at high temperatures to form chitosan[4] and acetic acid without change

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[2]Imms (17, p. 6): "Chitin is related chemically to the cartilage of vertebrates and also to mucin." This statement gives the impression that chitin is a protein, whereas it is essentially a polysaccharide and is related only to the carbohydrate part of glucoproteins from cartilage and mucin.

[3]Morgulis (34), who has written the only American paper on the constitution of chitin, is the only recent worker who doubts that the acetyl group is a constituent of the chitin molecule. He believes that acetic acid from acid or alkaline hydrolysis of chitin is a secondary decomposition product. The present writer believes that the evidence against Morgulis's view is stronger than that in its favor.

[4]Chitosan was discovered by Rouget (39) in 1859. He found that chitin which had been boiled in a very concentrated potassium-hydroxide solution became soluble in dilute organic acids. This modified chitin, as he called it, was colored violet by dilute solutions of iodine and acid, whereas chitin was stained brown. Modified chitin was not studied again until 1894 when Hoppe-Seyler (16) named it "chitosan." Von Fürth and Russo (14) showed that chitosan behaves chemically like an alkaloid, forming crystallizable salts with acids and being thrown out of acid solution by alkaloid precipitants. Löwy (31) studied the elementary composition and crystalline form of chitosan sulphate, which is one of the most stable and insoluble of the chitosan salts. The solubility of chitosan in dilute acids, its iodine-acid color reaction, and the characteristic properties of chitosan salts, particularly of chitosan sulphate, form the basis of the best modern microchemical tests for chitin.

in appearance[5]. Chitin is oxidized and dissolved at room temperature by a solution of sodium hypochlorite containing 5 per cent available chlorine[6]. Wester (52, p. 293) confirmed the reports of earlier workers that chitin is not attacked by mammalian digestive enzymes[7]. Chitin is broken down by *Bacillus chitinovorus* Benecke (3), which may be responsible for its decomposition in nature.

The specific rotatory power of chitin in hydrochloric acid (sp. gr. 1.16) solution is $[\alpha]_D^{20} -14.1°$, Irvine (18); its index of refraction is 1.525 ± .005, Becking and Chamberlin (2); and its specific gavity is 1.40, Sollas (46).

A mass of evidence, too great to be detailed here, indicates that chitin has the foregoing chemical and physical properties whether it is obtained from fungi, molluscs, annelids, or arthropods[8]; i. e., there is only one chitin. Possible exceptions to this rule have been reported recently for *Limulus* by Fränkel and Jellinek (13), for certain fungi by Dous and Ziegenspeck (10), and for the marine worm *Eunice* by Gonell (15, p. 21).

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[5]Imms (17, p. 7): "It [chitin] may be boiled in concentrated alkali for long periods without undergoing decomposition." If by "decomposition" Imms means disintegration, the statement is correct; but if the word has its usual sense of chemical change, the statement is wrong, because chitin may be decomposed under the foregoing conditions into chitosan and acetic acid.

[6]The solubility of chitin in sodium hypochlorite solution was first noted by Looss (30) in 1885, but his observation was discredited by Wester (52, p. 292), who asserted that pure chitin was not affected by this reagent at ordinary temperatures. More recently, Ito (19, p. 364) noted the solubility of chitin in cold sodium hypochlorite solution. The present writer confirmed Ito's observation, using a solution containing 5 per cent available chlorine. Pure chitin disappears rapidly at room temperature with evolution of gas. Natural cuticula is also completely decomposed.

[7]Although no cases of the digestion of chitin, by insects for its utilization as food are yet known, it is certain that some insects are able to dissolve chitin and lay it down again in a new form. The old chitinous endocuticula may practically disappear just before ecdysis. (Plotnikow (38, p. 339), Müller (35, p. 554)). The writer finds that the cast skin of the American cockroach consists almost entirely of exocuticula. Uvarov (Trans. Ent. Soc. London 1928, p. 300) mentions the formation of chitinous cocoon threads by a fungus feeding beetle larva and the softening or solution of the integument of a spider by a hymenopterous larva which consumes the entire body of its host.

[8]The most trustworthy and comprehensive surveys on the distribution of chitin in invertebrates are by Van Wisselingh (55, p. 679-683) and Wester (53); in fungi by Van Wisselingh (55, p. 658-676) and Von Wettstein (54).

A METHOD FOR THE DETECTION OF CHITIN IN INSECTS[9]

A milligram or less of insect cuticula or intima, freed from tissue or food as far as possible, is placed in a 1.9 × 7.6 cm. (¾ × 3 inch) shell vial containing about 3 cc. of potassium hydroxide solution, saturated at room temperature[10]. The vial is closed by a rubber stopper bearing a Bunsen valve[11] and is lowered into a beaker containing glycerine. It is supported by a clamp so that the alkali lies below the surface of the glycerine and the vial does not touch the bottom or sides of the beaker. A thermometer is suspended in the glycerine and the bath is heated slowly (in 15 or 20 minutes) to 160° C. By alternately removing and replacing the Bunsen burner, the bath is held at this temperature for 15 minutes. The vial is then allowed to cool to room temperature and the contents are poured out into a watch glass. If the material has dissolved, no chitin was present. If there is insoluble material, it is transferred to 95 per cent alcohol and is passed through 70 per cent, 50 per cent, and 30 per cent alcohol to water, in which it is washed. It is then ready to be tested for chitin on glass slides under a compound microscope.

If the material consists entirely of chitosan, the following reactions occur: A piece of the material dissolves in a drop of 3 per cent acetic acid, from which solution a white precipitate (chitosan sulphate) is obtained by the addition of a drop of 1 per cent sulphuric acid. Another piece if covered by a drop of 0.2 per cent iodine in potassium iodide solution is stained

[9]Since the writer believes that his method is simple enough to be used as a laboratory exercise by students of elementary entomology, details of the method, many of which might be modified, are described without comments or digressions. In the next section reasons for various recommendations will be given and the relative merits of this and other methods will be discussed.

[10]Weights of potassium hydroxide and water to be used for the solution vary, of course, with the purity of the former and the average room temperature. But to give an idea of the relative quantities it may be stated that the writer made a stock solution by dissolving 400 grams of 85–88 per cent potassium hydroxide in 250 cc. of water. The solution was stirred and cooled to room temperature and stored in a paraffin lined bottle closed by a rubber stopper. To line a bottle with paraffin, clean, dry, and warm it, and pour into it 58° paraffin a little above its melting point. Place the bottle on its side and roll it back and forth until the walls are evenly coated; then stand it upright and let the rest of the paraffin solidify on the bottom.

[11]Take 5 centimeters of rubber tubing, force the pointed blade of a pair of scissors through the wall near the center of the piece, and make a ½ cm. slit in the wall, lengthwise of the tube. Attach one end of the tube to a short piece of glass tubing projecting from the rubber stopper. Close the other end with a bit of glass rod. Be sure that the slit is not covered by the glass tube or rod.

brown. This drop is drawn off by a capillary tube[12] and is replaced by a drop of 1 per cent sulphuric acid. Instantly the material assumes a deep reddish violet color where it is thin enough to be translucent. Thicker parts appear black but they will show the violet color after being washed sufficiently in water. The dilute acid or water is replaced by a drop of 75 per cent (by volume) sulphuric acid. The color disappears as the object goes slowly into solution. The slide is set aside upon a watch glass containing water and is covered by another watch glass. When it is examined again after two or three hours or on the next day, the drop appears cloudy. It is washed from the slide by a stream of distilled water and the slide is dried. A cloudy film remains on the spot which the drop occupied. The compound microscope with 4 mm. objective resolves the film into colorless spherical crystals (probably chitosan sulphate) of various diameters not exceeding 20μ and usually much smaller. A drop of a 0.1 per cent aqueous solution of an acid dye, e. g., rose bengal, is placed on the film. The dye, which stains the crystals almost instantly, is washed off the slide by a stream of distilled water. After the slide has dried, a permanent mount of the stained crystals is made in balsam. If the chitin in the object to be tested has been only partially converted to chitosan by alkali treatment, the foregoing reactions will be obtained, except that the object will not dissolve completely in 3 per cent acetic acid.

The only other organic compound known to the writer which might be present with chitosan is cellulose. This may contaminate a chitosan preparation in the form of fibers from lens paper, filter paper, or toweling, or as the remains of plant food in the alimentary tract of insects. It does not dissolve in dilute acetic acid and is not colored by iodine-dilute acid, but swells and turns blue when 75 per cent sulphuric acid is added to decolorize and dissolve the chitosan. Moreover, cellulose does not yield spherical crystals, nor crystals of any kind, under the treatment by which they are formed from chitosan and sulphuric acid. Cellulose is not stained by acid dyes, except, as in the case of congo red, when salts mixed with the acid dyes alter their normal staining reactions.

[12]The writer uses a single pipette for all solutions. It is simply a piece of ordinary 5 mm. glass tubing drawn to a fine tip at one end and attached to a piece of rubber tubing at the other. Mouth pressure or suction on the rubber tube is used to place drops on or remove them from the slide. The pipette is rinsed with water and solution in passing from one solution to another.

DISCUSSION OF METHODS FOR THE DETECTION OF CHITIN.

Preliminary alkali treatment of material suspected of being chitinous serves a threefold purpose: First, complete solution of the material demonstrates the absence of chitin; second, organic substances intimately associated with chitin are usually removed, or at least eliminated to an extent which prevents their interference with subsequent tests for chitin; third, chitin is changed to a more reactive substance, chitosan, on the properties of which are based the most dependable microchemical tests for chitin.

It would be expected from the general effect of temperature and concentration on the rate of chemical reactions that the higher the temperature and the concentration of alkali the more rapidly and completely these results could be obtained. This is borne out by experience in converting chitin to chitosan, although no comprehensive experiments on this point have yet been made. The limiting temperature above which chitosan is completely broken down by alkali is 184° C. according to Hoppe-Seyler (16, p. 3,331). The highest concentration of alkali which might theoretically be used is that from which potassium hydroxide crystallizes out at 180° C. But it is impracticable to use such a high concentration.

Van Wisselingh (55) in 1898 was the first to prepare chitosan especially for microchemical tests. He heated chitinous material in concentrated alkali (a 50 or 60 per cent solution was later recommended) in sealed tubes to 160° C., and at that temperature obtained rapid and complete conversion of chitin to chitosan. The use of sealed tubes instead of open vessels prevented boiling and evaporation of water from the solution and thus avoided possible mechanical injury to delicate material either by its violent movement in a boiling solution or by its inclusion among crystals from the more concentrated cooled solution. This is an excellent method, which usually gives an experienced investigator no trouble, but it is not one to place in the hands of students, because improperly sealed or weak tubes may, and do, explode. The writer has had one explosion and was fortunate in having escaped injury. Partly for this reason and partly for following the line of least resistance, Vouk (50), Spek (47, p. 327), and Schulze (41, p. 389) proposed modifications of Van Wisselingh's method in all of which the

objects were heated in open vessels. Vouk and Schulze boiled their solutions; Spek evaporated his solutions on slides to dryness. Kunike (28, p. 235) advised using a 5–20 per cent alkali solution, treating the material in stoppered flasks for several days at 60° C. Although all of these workers were able to obtain more or less chitosan, they did not duplicate at atmosperic pressure Van Wisselingh's excellent conditions for its formation.

In 1924 Van Wisselingh (57, p. 178) justly criticized the simplified methods of others and defended his own, which he had not been able to improve in 26 years; and the latest paper (1928) on the detection of chitin, by Kühnelt (25), vigorously supports the original Van Wisselingh method. Kühnelt (p. 380) says that the heating of small objects in open vessels results in injury to them by the *unavoidable* boiling of the solution. Apparently it has never occurred to workers on chitin that boiling can be avoided at 160° C. under normal atmospheric pressure simply by increasing the concentration of potassium hydroxide[13] to that of a solution saturated at room temperature. And when such a solution is heated in tubes closed by Bunsen valves, the loss of water by evaporation is so slight, even during an hour at 160° C., that the tubes can be cooled again to room temperature without causing the solute to crystallize. In this way the present writer has duplicated at atmospheric pressure the conditions of Van Wisselingh's sealed tube method and has treated successfully the most delicate as well as the most resistant insect structures; e. g., peritrophic membranes and beetle elytra.

Kühnelt (25, p. 380) asserts reasonably enough, but without proof, that the hydrolysis of chitin to chitosan is slower at atmospheric pressure than in sealed tubes. The present writer compared the rate of chitosan formation in Bunsen tubes and sealed tubes, using a saturated solution in the former and 50 per cent alkali[14], as recommended by Kühnelt, in the latter. A single piece of pure crab chitin was cut into six parts of equal size. Three pieces were placed in Bunsen tubes and three in

[13]Potassium hydroxide cannot be replaced by sodium hydroxide in the writer's method.

[14]The undefined expression, "50 per cent potassium hydroxide solution," may have such a variety of meanings that the writer does not know whether the solution he prepared, containing 1 part by weight of 85–88 per cent potassium hydroxide and 1 part by weight of water, is the same as that recommended by Kühnelt.

sealed tubes. All six tubes were heated in the same bath. When the temperature of the bath reached 160° C. after 20 minutes preheating, a Bunsen tube and a sealed tube were removed and cooled rapidly. At the end of 10 minutes at 160° C. another pair were removed, and the last pair were taken out at the end of 15 minutes at 160° C. All of the pieces treated in Bunsen tubes dissolved quickly and completely in 3 per cent acetic acid, whereas none of those treated in sealed tubes did so, a small portion of each remaining undissolved in the acid the next morning. The Bunsen tube method is, therefore, faster than the sealed tube method when 50 per cent alkali is used in the latter.

The writer can think of only one possible advantage that sealed tubes may have over Bunsen tubes. Pressure within the former might prevent the expansion of gases within the material and its consequent swelling or disruption. Although this may be the case in fungi, with which Van Wisselingh worked, where chitin occurs in the cell walls, it does not seem to be a disturbing factor in chitinous insect material when parts of cuticula or intima are tested or whole insects are opened and the tissues removed as far as possible before treatment.

Kunike (28, p. 235) condemns the use of concentrated alkali, which the writer has just recommended, because it does not remove substances associated with chitin. Unfortunately, no proof for this statement is given. The present writer does not know to what extent admixtures[15], as the associated substances may be called, are dissolved by the Bunsen tube treatment; but he does know that chitinous objects so treated give the same specific tests as the most carefully prepared, reprecipitated, and washed chitosan. In other words, if admixtures are present after the Bunsen tube treatment, they do not interfere with subsequent tests for chitin. In every case yet tested by the writer, the Bunsen tube treatment is successful wherever other methods succeed.

The transfer of delicate objects from concentrated alkali to water by way of alcohol was proposed by Van Wisselingh (55).

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[15]Schulze (40, p. 135) called the associated substances "Inkrusten," a term which has been used by all German writers since 1921. But the English equivalent of this term, "incrustations," is unsatisfactory, because it implies that these substances are laid down *upon* chitin after the latter has been formed by epidermal cells. It is probable, but not yet proved, that they are laid down *with* chitin and are most intimately associated with it.

In this way violent dilution stresses on the material are prevented, and the objects are hardened. The number of grades of alcohol to be used depends on the nature of the material.

The conversion of chitinous material into chitosan having been discussed, the microchemical reactions of chitosan will now be considered.

To Van Wisselingh (55) is also due the microchemical application of the violet color reaction with iodine-dilute acid for chitosan, used without change by the present writer. This reaction is remarkably uniform on chitosan of widely different origins. Iodine color reactions are not specific for particular polysaccharides, but the violet color on chitosan is practically specific, because only one other organic compound, cellulose, is known to withstand alkali treatment used for the preparation of chitosan, and its color reactions, already described, are quite different.

Schulze (41, p. 390) and Brunswik (8, p. 113) believe that chitin also may be colored violet by iodine-dilute acid. There is no reason why this should not be the case, but Kühnelt (25), who made a special effort to settle this point, found that pure chitin was invariably colored brown by iodine-dilute acid. The present writer agrees with Kühnelt and adds the observation chitin precipitated from its solution in concentrated hydrochloric acid, thoroughly washed in water, alcohol, and ether, and dried in a vacuum desiccator is also colored brown by iodine-dilute acid. Quantitative work on this question is, however, desirable.

The possiblity of the presence of some polysaccharide other than chitosan or cellulose in material to be tested for chitin makes it desirable to check the Van Wisselingh reaction by a more specific test. We are indebted to Brunswik (8) for the description of a microchemical method for obtaining characteristic crystals of chitosan sulphate from chitosan following the Van Wisselingh test. Brunswik recommended that the violet color be obtained by acidifying the test object with 10 per cent sulphuric acid, instead of 1 per cent acid, and that the object then be dissolved in this drop by heating the slide. Crystals of chitosan sulphate were then to be obtained by exceedingly slow cooling of the slide. The writer found it difficult to get crystals large enough for study, and experience and practice seem to be necessary for the successful operation of this method.

The writer's modification of it is so simple and certain that any student without experience could apply it successfully. His use of 75 per cent sulphuric acid has the additional advantage of revealing cellulose if it is present.

The writer noticed that spherites obtained by his dilution method were always circular in outline, whereas Brunswik's spherites obtained by cooling were always tetragonal. The

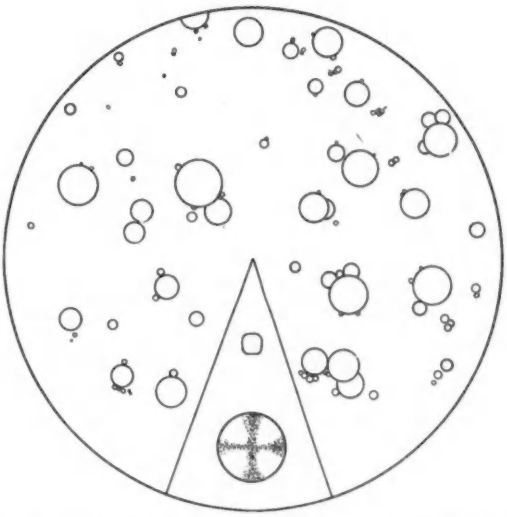

Figure 1. Spherites obtained by slow dilution of a solution of chitosan in 75 per cent sulphuric acid. One of the largest crystals obtained, 19μ in diameter, is shown in the sector to illustrate the appearance of the spherites under polarized light. The smaller crystal in the sector is the tetragonal spherite obtained by slow cooling of a solution of chitosan in dilute sulphuric acid.

two forms are shown in Figure 1. The tetragonal form has hitherto been considered characteristic of all chitosan salts. According to Löwy (31, p. 51) chitosan sulphate has exactly the same tetragonal form as chitosan hydrochloride figured on page 173 by Von Fürth and Russo (14). The present writer, therefore, hesitates to call his spherical crystals chitosan sulphate, although nothing is known which would lead us to believe that some other salt could crystallize out of a solution of pure chitosan in sulphuric acid. It would seem that the difference in appearance is due merely to the difference in con-

dition under which the crystals are formed. At least, it can be said in favor of their identity that both forms show the black (Brewster's) cross (Fig. 1) under polarized light, both seem to have the same index of refraction, 1.52–1.53[16] (convincingly accurate determinations could not be made on either form), and both are stained by the same acid dyes. Whether or not the spherical crystals are chemically the same as the tetragonal form, they are indicative of the presence of chitosan and hence of chitin. Neither chitin nor cellulose dissolved in 75 per cent sulphuric acid yield crystals of any kind by slow dilution of the solution. The same spherical crystals are obtained from crab and from insect chitosan.

The formation of sufficiently large spherical crystals results from the slow dilution of sulphuric acid solutions of chitosan. Slow dilution is accomplished automatically by the absorption of water from the air by the hygroscopic acid. The higher the concentration of chitosan in 75 per cent sulphuric acid, the less is the dilution needed to produce the crystals. In summer, when the relative humidity of the laboratory air is high, crystals were invariably obtained when the drop was exposed to the air of the room, but in winter, when the room is hot and relatively dry, crystals were formed only when the concentration of the solution of chitosan was very high. In order, therefore, to assure the formation of crystals, if chitosan is present, it is always desirable to let the slide stand over water.

The recommendation of 75 per cent sulphuric acid is based on tests of a series of concentrations from 25 per cent to concentrated acid. The latter can be used successfully, but a concentration of about 75 per cent by volume gave the best results. A drop no larger than necessary to cover the object should be used. It does not matter if the drop is not large enough to dissolve the entire object, for the chitosan residue will be washed off the slide with the drop and the crystals alone will remain.

Another excellent color reaction for chitosan devised by Van Wisselingh (56, p. 185) will be mentioned here because, in the writer's tests, it made visible certain structures of cockroach endocuticula. Chitosan forms an insoluble compound with

[16]The equipment and advice of Mr. C. M. Smith, of the Food, Drug, and Insecticide Administration of the United States Department of Agriculture, were generously placed at the disposal of the writer for the study of the optical properties of these crystals.

ferrocyanic acid. A drop of 1 per cent potassium ferrocyanide in dilute sulphuric acid is placed on the test object which is then thoroughly washed with water. The chitosan ferrocyanide formed on the surface of the object is invisible and must be developed, as it were. For this purpose a solution of a ferric salt, iron alum, is placed on the object and Prussian blue is formed on its surface in such a way that it appears to be stained with a blue dye. Permanent mounts of the results of this test can be made in balsam. Many other suggestions for microchemical chitosan reactions can be found in Van Wisselingh's papers (56, 57).

An entirely different method for preparing and testing chitinous material has been described, discussed, and applied by Schulze (40, 41, 42) from 1921 to the present time. Pigmented cuticula is bleached at room temperature in a solution of chlorine dioxide in acetic acid or, if naturally colorless, is allowed to stand for 24 hours in this reagent. It is then washed and placed for one minute in a solution of zinc chloriodide. While it is being washed in water again, the cuticula turns violet.

It is Schulze's theory that chlorine dioxide has a selective action on the substances of the cuticula. All substances other than chitin are supposed to be removed from the cuticula at room temperature more thoroughly than their removal can be accomplished by alkali at high temperature. The violet zinc chloriodide test is then given by pure, or nearly pure, chitin (not chitosan). In spite of its alleged powerful effect on cuticula, chlorine dioxide, as used by Schulze, is said to have no effect on insect tissues (a truly remarkable reagent!).

If Schulze's theory is correct and the zinc chloriodide test is specific for chitin, the Van Wesselingh and Brunswik tests are superfluous and relatively too troublesome to be used. For several years Schulze and his student Kunike (28) applied the new method enthusiastically, but without a critical examination of its chemical basis. In 1928 Kühnelt (25) published the first critique of Schulze's method. He came to the conclusion that, instead of being better than the Van Wisselingh-Brunswik methods, it is less dependable for the following reasons: Although the violet zinc chloriodide reaction is given faintly by pure chitin, its deep color in material treated by chlorine dioxide is due to adsorbed chlorine which is difficult to remove.

The zinc chloriodide test is not specific for chitin, but is given by other polysaccharides and even by certain inorganic substances. Finally, Schulze's method usually fails to detect chitin in the cuticula of the caterpillars *Bombyx mori* and *Dasychira pudibunda*, whereas, Van Wisselingh's alkali method, with pretreatment of this cuticula in glycerine at high temperature or by bleaching in potassium chlorate-hydrochloric acid, is always successful. The writer finds that the Bunsen tube treatment alone is sufficient preparation for the detection of chitin throughout the cuticula of *Bombyx mori*.

On the other hand Kühnelt showed that Van Wisselingh's method, with Kühnelt's pretreatment, makes it possible unfailingly to detect chitin in the exocuticula of certain beetle elytra, e. g., *Lucanus cervus*, which Schulze had asserted (40, p. 135; 41, p. 390) could be prepared successfully only by chlorine dioxide treatment. The writer found that the Bunsen tube treatment alone decolorized the thick, heavily pigmented tips of the elytra of *Lucanus cervus* within 15 minutes at 160° C. and converted chitin completely to chitosan. All chitinous layers of the elytra, including the exocuticula, gave the characteristic violet reaction with iodine-dilute acid.

The writer does not mean to imply by the foregoing that Schulze's method is not good, but that at the present time it cannot be used with confidence because of the lack of knowledge of the effect of chlorine dioxide on insect cuticula. The only evidence offered by Schulze for the ability of chlorine dioxide to remove "gründlich" from cuticula those substances associated with chitin, is the fact that treated cuticula dissolves in concentrated sulphuric acid to a colorless solution, whereas untreated cuticula, whether pigmented or not, gives a brown solution. But it has not been proved that chitin is the only substance in the cuticula which does not give a brown solution. Moreover, it is not known what effect, if any, chlorine dioxide has on chitin itself. Since sodium hypochlorite can oxidize chitin, it is reasonable to suppose that other chlorine-oxygen compounds might have some effect on it. Quantitative work on these questions is needed.

Other color tests for chitin, the α and β naphthol tests of Schulze and Kunike (44) and the thymol test of Kraft (23) need not be discussed here because they are general carbohydrate reactions.

THE QUALITATIVE DISTRIBUTION OF CHITIN IN INSECTS.

Two general questions will first be considered: Whether chitin may be absent, and whether it may occur in a pure state in certain areas of insect cuticula.

According to statements[17] in recent text-books, chitin occurs only in sclerites; membranes are non-chitinized. Such views, however, are not based on chemical tests, but on the preconceived idea that the hardening of sclerites, following ecdysis, is due to the deposition or formation of chitin within them, which leads to the assumption that flexible membranes do not contain chitin.

What are the facts? The discoverer of chitin (36, p. 37) showed that an *entire* insect exoskeleton could be prepared by maceration in alkali and recommended the method to morphologists. Countless exoskeletons have been prepared by alkali treatment since the time of Odier, and so far as the writer knows, the solution of cuticular membranes has never been recorded. The membranes, therefore, contain chitin, cellulose, or some substance, still unknown, which is insoluble in alkali. The presumption in favor of chitin was strong before the advent of specific chitin tests, but it was not until the beginning of the present century that its presence was demonstrated beyond reasonable doubt by chitosan reactions in the cuticular membranes of representatives of different orders—in *Cynips* and *Musca* by Van Wisselingh (55, p. 380) and in *Periplaneta*, *Dytiscus*, and *Melolontha* by Wester (53, p. 543). The present writer believes that further confirmation of the presence of chitin in cuticular membranes is unnecessary except in one special case.

In the membranous cuticula of the enlarged abdomen of the termite queen[18], if anywhere in the exoskeleton of insects,

[17]Imms (17, p. 6): "When newly formed it [the cuticula] is flexible and elastic and it remains in this condition as the intersegmental membranes, the articular membranes of the appendages, and in other situations. For the most part, however, the cuticle forms a hard inelastic exoskeleton which is due to its becoming permeated with a substance termed chitin. The nature of the change is not known, nevertheless both chitinized and non-chitinized cuticle are of general occurrence." Comstock (9, p. 30) makes practically the same statement, but on page 34 contradicts himself: "The conjunctivæ are less densely chitinized than other portions of the cuticula."

[18]The writer is indebted to Dr. T. E. Snyder, of the Bureau of Entomology, for providing a specimen of a mature termite queen.

one might expect chitin to be replaced by substances more susceptible to chemical and physical change, because this cuticula cannot stretch to its final enormous dimensions. It must grow continuously, if the insect does not molt, and there is no evidence, direct or indirect, for ecdysis in termite queens. Yet the writer finds that the entire cuticula of the abdomen is chitinous.

Since chitin seems always to be present in insect cuticula, one wonders whether it ever occurs without admixtures. Such a case is not known, for it is usually necessary to treat cuticula in some way for the removal of admixtures before it can be tested successfully for chitin. In the few cases where naturally colorless cuticula gives the zinc chloriodide test for chitin without previous treatment, Schulze (41, p. 390) maintains that admixtures are present nevertheless[19]. The present writer finds that all cleaned and dried chitinous parts of the American cockroach lose weight after treatment in alkali; i. e., admixtures are dissolved. Numerous statements[20] in entomological literature which imply that certain cuticula consists of pure chitin are probably due not so much to the belief of the writers in the occurrence of pure chitin as to a carelessness of expression.

We have come to the conclusion that chitin, always accompanied by other substances, occurs throughout the exoskeleton. But does it occur in all layers[21] of the cuticula?

According to Kühnelt (26) the epicuticula does not contain chitin. He finds fatty acids and cholesterol in it. Its properties are similar in many respects to those of the cuticle of leaves.

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[19]Jacobs (20, p. 9) asserted that the intersegmental membranes of the honeybee consist of pure chitin because they give the zinc chloriodide test without previous treatment for the removal of admixtures. But the present writer found admixtures in this cuticula by treating it with concentrated nitric acid. It turns yellow, whereas pure chitin remains colorless.

[20]For example, Imms (17, p. 110) writes, "The innermost lining of a trachea is a layer of chitin. . . ." Comstock (9, p. 30) says, "In thin sheets it [chitin] is yellowish in color; thicker layers of it are black," implying that pigmented exocuticula is chitin. Lazarenko (29), throughout a long paper on the formation of cuticula by regenerating epithelium, calls the cuticula chitin. Entomologists who wish to refer to the material of the cuticula or intima, whatever may be its composition, should have a suitable name for it; e. g., hoplin (ὅπλον, armor). Chitin would bear the same relation to hoplin that cellulose does to wood, or collagen to cartilage, the former being in each case a well known component of the latter.

[21]Following the suggestion of Mr. R. E. Snodgrass, of the Bureau of Entomology, the writer calls the extremely thin outermost layer (Grenzlamelle) the epicuticula, the brittle, pigmented outer layer (epidermis, Pigmentschichte) the exocuticula, and the flexible, colorless inner layer (dermis, Hauptlage) the endocuticula.

No one seems to doubt that chitin is present in the exocuticula of insects, but we find in recent text-books [Comstock (9, p. 172), Mac Gillivray (32, p. 13), Snodgrass (45, p. 6)] that the endocuticula does not contain chitin but is much like cellulose. The source of this error seems to lie in the work of Ambronn (1). In 1890 Ambronn, a botanist, found that the endocuticula of grasshoppers and bees was colored violet by zinc chloriodide, a reagent which had long been used to demonstrate the presence of cellulose in plant tissues, with which it gives a somewhat similar color reaction. Ambronn, therefore, thought he had discovered cellulose in insects. In 1894 Vosseler (49) asserted before the Württemberg Natural History Society that the endocuticula of insects is like cellulose in every respect. The abstract of this paper in the proceedings of the Society does not indicate that he referred to the work of Ambronn or that he himself had made any experiments to support his statement. Packard (37, p. 30), in his text-book of 1898, quoted Vosseler: "Besides the external chitinous layer, there is an inner layer which agrees entirely with cellulose." In 1906 Tower (48, p. 184) repeated the same statement as if he had confirmed its truth: "This [inner] layer is, as is well known (Vosseler, Tower), a carbohydrate allied to tunicin." But if Tower did test the endocuticula, he did not describe his methods in his earlier papers. The later text-book writers seem to have drawn their misinformation from Tower, but the truth of the matter was known long before their books were written. Soon after the publication of Ambronn's work, Krawkow (24) and Zander (60) showed that the endocuticula of arthropods contains chitin, not cellulose. Wester in 1910 (53, p. 550) proved conclusively that cellulose does not occur in the cuticula of several species of insects. Kunike (28), using methods which would have detected cellulose if it had been present, did not find it in a large series of insects. As a matter of fact, it is generally easier to detect chitin in the endocuticula of insects than in the exocuticula.

We turn now to special questions of a controversial nature. According to Imms (17, p. 101) there are two types of peritrophic membranes. The first is supposed to be continuously secreted at the junction of the fore-intestine and mid-intestine and "on account of its resistance to the action of alkalies, it is inferred to be of a chitinous nature." A peritrophic membrane

of this type from *Periplaneta* was shown to be chitinous by Wester (53, p. 543). His observation was confirmed by the present writer. Imms's second type, represented in the honeybee, is supposed to be formed by the delamination of the inner or free margins of the cells lining the mid-intestine. He says, "It is evident that in these instances it is a non-chitinized structure quite different from the usual type of peritrophic membrane described above." But the present writer finds chitin in the peritrophic membrane of the honeybee. It reacts in quite the same way as the membrane of the American cockroach. Snodgrass believes that all peritrophic membranes are of the second type. He writes (45, p. 162), "The old idea that the peritrophic membrane of insects is a backward prolongation of the chitinous intima of the proventriculus has been discredited in all recent investigations on its origin." If he is correct, we must admit that the ability of the cells of the mid-intestine to form chitin is quite general among insects.

All text-book writers seem to agree that the intima of tracheæ is chitinous. Since it is easy to demonstrate the presence of chitin in the larger tracheæ of the American cockroach, the present writer anticipated no difficulty in detecting it in the tracheæ of other insects. The air sacs of the house fly and tracheæ attached to them were tested because Van Wisselingh (55, p. 682) was unable to find chitin in them. Although repeated tests were made on this material and on the air sacs of the honeybee with the attached tracheæ, the present writer could not detect chitin in them. It is the more surprising, because taenidia occur in the intima of this material, except in the air sacs of the honeybee. The problem of the distribution of chitin in the tracheæ of insects has as yet hardly been touched.

Wester (53, p. 548) seems to be the only one who has tested the eggshells of insects for chitin by the use of chitosan reactions. He found no chitin in the eggshells of several species of Lepidopters. The present writer tested the eggshells of a grasshopper, *Melanoplus differentialis*, and of the American cockroach. The chorion does not contain chitin, but when the egg has developed to a point where the blastoderm cells have laid down a membrane upon the chorion, that membrane contains chitin.

Cockroach oothecæ were thought by Duchamp (11), who first studied them chemically, to be chitinous, and were called chitinous by several later writers. Ito (19, p. 364) in 1924 compared the solubility of oothecæ and chitin in various reagents and decided that oothecæ were not chitinous. The present writer agrees with him, but could not confirm his observation that oothecæ are completely soluble in alkali. After treatment in Bunsen tubes for an hour at 160° C., a colorless, ragged, alveolar membrane remains. It gives none of the chitosan reactions. One specimen so treated was placed in a potassium chlorate-hydrochloric acid mixture for several days. It was treated again in the Bunsen tube, but gave no chitosan reactions. It did not dissolve on standing in 75 per cent sulphuric acid.

The scabs which form over wounds in the cuticula of the American cockroach do not contain chitin.

THE QUANTITATIVE ESTIMATION OF CHITIN IN INSECTS.

The obvious way to determine the percentage of chitin in cuticula is to clean, dry, and weigh the cuticula, dissolve out admixtures by alkali treatment, and wash, dry, and weigh again. But Wester (52, p. 293) pointed out that accurate determinations cannot be made in this way because we have no means of knowing when, or whether, all admixtures are removed or how much chitosan is formed in the process. Bernhart (4) attempted to estimate the percentage of chitin in ergot by dissolving the weighed, alkali-treated material in concentrated hydrochloric acid and weighing chitin precipitated by dilution in the cold. But some loss may take place through hydrolysis or incomplete precipitation of chitin. It seems feasible also to convert chitin completely to chitosan, weigh, and multiply by a factor to get the weight of chitin. But the value of the factor is uncertain and admixtures might not be completely removed.

Since errors can hardly be avoided, the writer has tried to use the first and simplest method in such a way as to remove admixtures with the formation of as little chitosan as possible. Abdominal cuticula of the American cockroach was freed from tissue by scraping it under water with a rather blunt scalpel. The work was carried on very carefully under a binocular microscope until not a visible trace of tissue remained. Since

this operation is tedious and time-consuming, each determination was made on material from a single insect. Not more than 9 mg. (whole sclerites) nor less than 0.4 mg. (intersegmental membranes) of cleaned material in pieces of a size that could be seen and handled was dried in a vacuum desiccator and weighed on a microbalance to within 0.01 mg. The pieces were allowed to stand in a potassium hydroxide solution (concentration, 15–20 grams per 100 cc. water) in an oven at about 60° C., for 2 weeks. Under these conditions pigmented parts are decolorized in 2 or 3 days. At the end of the period of treatment, the pieces were transferred to water. All transfers were made with forceps, under a microscope to be sure that no pieces were overlooked. They were then passed through 4 dishes of water and were allowed to stand over night in water; then through 2 dishes of absolute alcohol to ether, which on evaporation left them snowy white. After standing in a vacuum desiccator for several days, the pieces were weighed again.

Some chitosan was formed in this material, because spherites were obtained from its solution in sulphuric acid, but the conversion was not complete, because it did not dissolve appreciably in dilute acetic acid. Although admixtures might not have been completely removed, the following observations indicate a fairly thorough purification: Two sets of pieces which weighed 1.57 and 2.84 mg. respectively after two weeks' treatment weighed 1.55 and 2.78 mg. after two weeks' further treatment. The original weights were 4.21 and 8.52 mg. After the foregoing treatment Millon's test for proteins in the cuticula was negative, and no visible ash was left after ignition. For the benefit of those who have confidence in the sulphuric-acid test for admixtures, it might be added that treated material gave a colorless solution in concentrated sulphuric acid.

By the foregoing method the abdominal sclerites of the American cockroach were found to contain about 35 per cent chitin. The writer knows of only two other determinations[22]

[22]There are a number of chitin determinations on record, based on the live weight or dry weight of whole insects. Bounoure (5) analyzed 38 species of Coleoptera and found that the percentage of chitin on a live weight basis ranged between 5 and 15 per cent, being higher for phytophagous beetles. On a dry weight basis, Wolff, Funke, and Dittmann (58, p. 251) found 16 per cent in May beetles, Zaitschek (59, p. 615) 8 per cent in May flies, and Wester (52, p. 293) 10 per cent in cantharids.

of the percentage of chitin in insect cuticula. Odier (36, p. 33) found 29 per cent in elytra of May beetles and Komori (22) 37 per cent in the pupal skins of cicadas. The figures indicate from 30–40 per cent chitin and 60–70 per cent admixtures in insect cuticula. In view of the predominance of admixtures, it might be expected that they would contribute to, or determine, some of the important properties of cuticula.

THE IRRELATION OF "CHITINIZATION" TO HARDNESS AND PIGMENTATION OF THE CUTICULA OF THE AMERICAN COCKROACH.

An impression has persisted in the minds of entomologists up to the present time[23] that the inflexibility and hardness of the sclerites of insects are caused by the presence of chitin in them. And since the hard exocuticula is usually pigmented, entomologists have been accustomed to associate pigmentation with chitinization. Taxonomists and morphologists have accepted this alleged relationship without question and have been accustomed to describe parts of the exoskeleton as heavily chitinized, weakly chitinized, or non-chitinized according to the relative flexibility or pigmentation (particularly the latter) of the parts.

Several facts are already known which cast doubt on this supposed relationship and none support it. First, alkali treatment makes hard, brittle cuticula flexible. The obvious explanation is that alkali removes admixtures which cause the hardness of exocuticula. Indeed, because of the softening effect of alkali treatment, one entomologist confessed to the writer that he had though that the chitin must be removed by the alkali. Of course, it might be argued that inter-molecular or intra-molecular changes, and not the removal of a specific hard substance, softens cuticula. Second, non-chitinized areas, with the possible exception of pores, are not known to occur in the exoskeleton of insects. It does not seem reasonable to suppose that the hardness of exocuticula is due to chitin, since it is also present in soft parts, some of which, as the endocuticula, are usually thicker than the exocuticula. Comstock

[23]Metcalf and Flint (33, p. 72), in 1928, say: "This change from flexible to stiff cuticula is due to a chemical process and the hard material formed is called chitin."

(9, p. 34) explains away this difficulty by assuming that the flexible parts are less densely chitinized.

Ferris and Chamberlin (12) rightly considered the foregoing reasons sufficient for protesting against further use of the terms "chitinized" and "non-chitinized" to indicate relative hardness and pigmentation of cuticula. To replace them they proposed the logical adjectives "sclerotic" and "sclerotized[24]." They perceived the likelihood that admixtures are the cause of hardness. Schulze (40, p. 135) had long ago taken it for granted, for he speaks of "härtende Inkrusten."

The following facts, already known, are in favor of the view that certain admixtures are the cause of inflexibility and hardness. It is easy to find chitin in flexible cuticula but it is often difficult to detect it in hard exocuticula, presumably because of the predominance of admixtures in the latter. Certain hard, pigmented structures, such as cockroach oothecaæ, which would certainly be called heavily chitinized by a morphologist, do not contain chitin.

However convincing the foregoing qualitative evidence may seem, it might still be argued that the hard substance of the ootheca may be quite different from that of the exocuticula of the cockroach, and that the exocuticula may be more "densely chitinized" than the endocuticula and the intersegmental membranes. The writer, therefore, decided to attempt the determination of the percentage of chitin in exocuticula and endocuticula of the American cockroach and in the intersegmental membranes of this insect.

With a sharp scalpel the endocuticula was stripped as completely as possible[25] from the exocuticula and the percentage of chitin was estimated in the two layers as already described. Three sets of determinations were made, each on material from a different insect. The exocuticula contained

[24]It is interesting to note that American entomologists are not alone in their confusion about chitinization. In commenting on an illuminating talk by Schulze (43), Hase said, "Wir haben gehört, dass am Chitin eigentlich nur das wenigste 'Chitin' ist. Wie soll man unter diesen Umständen in Zukunft Angaben wie 'starke Chitinisierung' und ähnlich ausdrücken, um wissenschaftlich einwandfrei zu sprechen?" Ferris and Chamberlin have given an answer to the question.

[25]If cuticula is allowed to stand for several days in a mixture of glycerine and hydrochloric acid, as proposed by Kunike (28, p. 245), and then soaked in water, an easy and perfect separation of the two layers can be obtained. The present writer doubts, however, that admixtures are not "zerstört," as claimed by Kunike, because untreated endocuticula contained not more than 65 per cent of chitin, whereas, after treatment in Kunike's mixture, it contained as much as 91 per cent.

23 per cent, 22 per cent, and 22 per cent, the endocuticula 65 per cent, 57 per cent, and 57 per cent respectively, a significant difference. The inflexible pigmented layer proved to be "weakly chitinized" and the flexible colorless layer "heavily chitinized[26]." It seems to the writer that this quantitative evidence in conjunction with the more general qualitative evidence already mentioned is incontrovertible proof that the hardness and inflexibility of the exocuticula are due not to chitin but to certain admixtures.[27]

The so-called "non-chitinized" intersegmental membranes contain at least 27 per cent of chitin. It is so difficult to clean and handle such delicate material that this figure should probably be higher. It is not to be expected that, because the membranes are flexible, the percentage of chitin in them should be as high as it is in endocuticula. Exocuticula is generally present in intersegmental membranes, but, either because of its thinness or because of its discontinuous structure, called "Kegelbildung" by Kühnelt (27), it does not interfere with flexibility.

There is no relation between pigmentation and chitinization of structures in the American cockroach. For example, heavily pigmented oothecæ contain no chitin; exposed regions of abdominal sclerites, which superficially look the same, contain 33 per cent; the nearly colorless regions, covered by the preceding sclerites, contain 37 per cent; the colorless cast skins of newly hatched cockroaches contain 35 per cent.

It has been shown that the inflexibility of the cuticula of the American cockroach is not due to chitin nor is pigmentation associated with chitin. But it is still necessary to test the assumption of Imms (17, p. 6) that shortly after ecdysis and during the hardening process the cuticula becomes "permeated" with chitin. The present writer was fortunate to have observed

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[26]In agreement with this fact Kühnelt (27, p. 247) says of the endocuticula, "In chemischer Hinsicht zeichnet sich die Hauptlage durch das starke Hervortreten des Chitins aus, so das andere Stoffe nur eine ganz untergeordnete Rolle spielen." His statement, however, is apparently based on qualitative tests.

[27]Nothing specific is yet known about the chemical composition of admixtures, but proteins and carbohydrates can always be detected by general qualitative tests. It would seem logical to look for a scleroprotein as the specific hardening agent. Nothing is known either about the nature of the hardening process. It might be studied to advantage in cockroach oothecæ, where chitin does not occur, because the hardening material secreted by gland cells might be qualitatively the same as that secreted by epidermal cells.

a large cockroach nymph in the act of molting. Immediately after the insect was free, it was chloroformed and the flexible colorless abdominal sclerites were carefully prepared for analysis. This material contained an amount of chitin, 35 per cent, which appears to be normal for hardened cuticula. Therefore, it can neither be said that chitin permeates the admixtures at the time of hardening nor that admixtures permeate chitin, a view taken by Ferris and Chamberlin (12, p. 214). It seems more probable that chitin and admixtures are formed concurrently and are laid down in intimate association in about the same proportions in which they are subsequently found in hardened cuticula. The hardening process must consist in some change in admixtures which are present in the cuticula when the process begins.

SUMMARY.

The following modification of the Van Wisselingh-Brunswik tests for chitin is recommended: Material suspected of being chitinous is placed in potassium-hydroxide solution saturated at room temperature and kept at 160° C. for 15 minutes in a tube closed by a Bunsen valve. Following the iodine-dilute-acid test, the material is dissolved on the slide at room temperature in a drop of 75 per cent (by volume) sulphuric acid. Spherical crystals, precipitated by slow dilution of the drop in moist air, cling to the slide, where they may be washed, stained with an acid dye, and mounted in balsam.

By this method chitin was found throughout the exoskeleton of several species of insects, in the peritrophic membrane of the American cockroach and honeybee, and in the blastoderm membrane of cockroach and grasshopper eggs. Chitin could not be detected in the chorion of these eggs, in the air sacs and attached tracheæ of the house fly and honeybee, in the ootheca of the American cockroach, or in wound scabs of this insect.

The prevalent idea that chitin causes the hardness and inflexibility of insect exocuticula is no longer tenable. It was shown that the so-called "heavily chitinized," hard, pigmented exocuticula of the American cockroach contains about 22 per cent chitin, whereas the "non-chitinized," flexible, colorless endocuticula contains about 60 per cent. No relation was found between pigmentation and chitinization in the cuticula of the American cockroach. Adjacent pigmented and colorless areas

of abdominal cuticula contain about the same percentage of chitin, 35 per cent. The hardening of the exocuticula is caused by a chemical or physical change in certain substances intimately associated with chitin, which are present with it in the cuticula when the hardening process begins.

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BOOK REVIEW.

THE PROBLEMS OF APPLIED ENTOMOLOGY. By ROBERT A. WARDLE, M. Sc. McGraw-Hill Book Co. New York. pp. I–XII–587.

This very comprehensive survey of the present important problems in entomology discusses in the first part the general problems under such headings as Host Resistance, Climatic Resistance, Tropic Behavior, Disease, Parasites and Predators, Theory of Insecticides, Stomach Poisons, Contact Insecticides, Fumigants and Combination Insecticides and Cultural Influence and, in the second part, the problems of the larger geographical areas with the peculiar conditions pertaining to them. The third part includes a very carefully classified bibliography and index.

H. O.

COLEOPTERA TAKEN FROM BAIT-TRAPS.[1]

S. W. Frost and Henry Dietrich.

The Coleoptera in question were taken from more than 1000 traps operated in a peach orchard near Arendtsville, Adams Co[2]., Pennsylvania during the seasons 1926, 1927 and 1928. The traps consisted of fermenting sugar or molasses solutions placed in number ten tin pails, hung six or seven feet high on the trees. They were under close observation from March 15 to November 1, and were replenished every three or four weeks in order to keep them fresh and active. The beetles were secured by straining them from the pails each week and returning the baits to the pails for further catches. An 18 mesh sieve was found satisfactory for straining out the larger insects but one of finer mesh is recommended for micro-coleoptera and smaller insects. The Coleoptera were taken incidentally as a part of a larger project on the value and use of baits for trapping oriental fruit moths. The determinations of the species were made by Mr. Henry Dietrich with the assistance, in a few cases, of Mr. F. C. Fletcher.

Space does not permit a detailed discussion of the numerous baits used in trapping the beetles, but a few general remarks may not be amiss. Some idea of these baits can be securred by reference to three papers by the senior author[3]. For general purposes, molasses 1 part and water twenty parts was found most satisfactory. There are three distinct periods during the operation of these baits; (1) a short period of alcoholic fermentation lasting one or two days during warm weather; (2) a period of acetic fermentation lasting for three or four weeks; and (3) a period of putrification during which the bait lost its attractiveness for most insects. During the first and early part of the second periods, Nitidulidæ and some Scarabaeidæ, which naturally visit flowers, came freely to the baits.

[1]Publication authorized by the Director of the Pennsylvania Agricultural Experiment Station as Technical Paper No. 468.

[2]Except a few records from Aspers or Midvale, Pa., which have been designated.

[3]Frost, S. W., Jl. Econ. Ent. 19: 440–450, 1926; 20: 167–174. 1927; 21: 339–348, 1928.

During the third period, Silphidæ and certain Scarabaeidæ were attracted. As a rule baits were not continued after putrification developed, and as a result, few of the filth-loving beetles were taken.

Liquid baits offer a profitable method of collecting beetles of certain families. Sugaring for moths is an old practice and the use of vinegar or brown sugar to trap beetles as Nitidulidæ

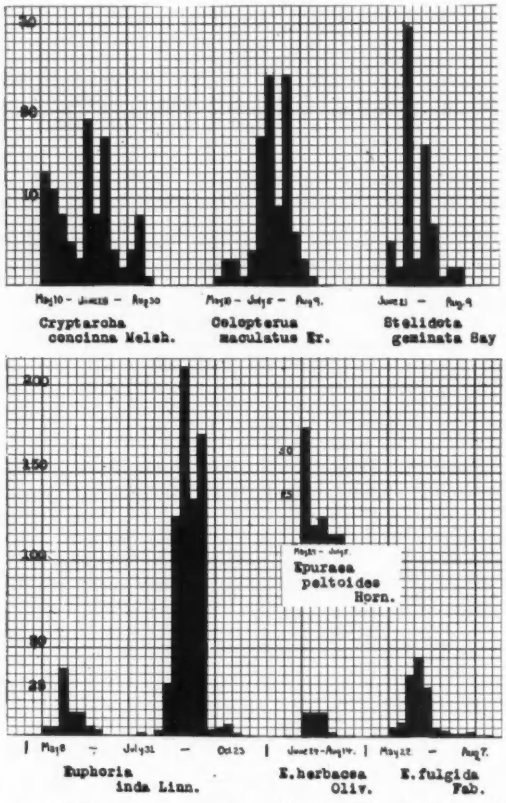

FIG. 1. Relative catches of seven species of beetles taken in bait pails. *Euphoria inda* apparently has two broods.

Space has permitted the mention of only a few of the more interesting species taken in baits. Much might be learned from a study of the occurance of some of the more common species. The accompanying figure shows in a graphic way the complete records of seven species taken during one summer. Most of them show but one brood occuring over a definte period of time. *Euphoria inda* apparently has two broods or at least is much more abundant during August and September.

is well known, but the use of liquid bait as traps is somewhat new. Champlain and Kirk (1926)[4] have summarized catches from such baits. The expenditure of labor, time and materials for this method of collecting is insignificant, and there are wonderful possibilities of adapting it for general collecting, especially if such traps are operated in wooded places, swamps etc.

Representatives of 40 of the 111 families of Coleoptera have been taken in baits and practically every major family is represented. A total of 188 genera and 258 species, many of which are rare, have been collected in this way. The Carabidæ, Staphylinidæ, Elateridæ, Nitidulidæ, Cerambycidæ, Chrysomelidæ, Curculionidæ, and Scolytidæ were most conspicuous in number of genera and species represented while the Staphylinidæ, Nitidulidæ and Cerambycidæ were most conspicuous in the number of individuals taken. The abundance of some species indicates that they are attracted by the baits, while the great variety of genera and small number of individuals among families such as the Chrysomelidæ would indicate that these species fell into the trap by accident. It would be impossible to list all of the species taken in the baits but some of the rarer species are worth mentioning. The following list plainly shows where baits are of value in collecting Coleoptera:

COLEOPTERA TAKEN IN BAIT PAILS, SUMMERS 1926, 1927 AND 1928.

FAMILY	NO. OF GENERA	NO. OF SPECIES	FAMILY	NO. OF GENERA	NO. OF SPECIES
Carabidæ	23	35	Monotomidæ	1	1
Hydrophilidæ	2	2	Cucujidæ	2	4
Silphidæ	3	3	Erotylidæ	2	2
Staphylinidæ	15	18	Cryptophagidæ	1	1
Histeridæ	3	4	Phalacridæ	1	1
Lampyridæ	1	1	Coccinellidæ	3	4
Cantharidæ	3	5	Alleculidæ	1	1
Malyridæ	1	1	Tenebrionidæ	2	2
Cleridæ	4	5	Lagriidæ	1	2
Corynetidæ	3	3	Melandryidæ	2	2
Cupesidæ	1	1	Anobiidæ	1	2
Mordellidæ	2	3	Bostrichidæ	3	3
Pyrochroidæ	1	1	Cisidæ	1	1
Anthicidæ	3	7	Scarabaeidæ	8	19
Elateridæ	11	18	Cerambycidæ	26	32
Melasidæ	3	3	Chrysomelidæ	17	19
Buprestidæ	4	4	Platystomidæ	1	1
Helodidæ	1	2	Curculionidæ	11	11
Dermestidæ	2	3	Scolytidæ	8	11
Byrrhidæ	1	1			
Nitidulidæ	9	19		188	258

[4]Ent. News 27: 288–291, 1926.

SEASONAL COLLECTIONS.

The Staphylinids were the first to make their appearance in the bait pails. As early as March 16th, several species of the genus Atheta, also *Philonthus micropthalmus* Horn, were captured in the baits. A few days later the common scarabaeid, *Aphodius granarius* Linn., was flying and numerous specimens were taken in the pails. On April 20th the Scolytids, *Monarthrum fasciatum* Say., and *Anisandrus pyri* Peck., made their appearance. Soon after this a host of carabids were attracted. From May until August Nitidulidæ were much in evidence. During May, June and July large numbers of Cantharus, especially the two species *C. bilineatus* Say., and *C. rectus* Melsh., were very prominent. During the summer Scarabaeidæ were taken in more or less numbers, the common flower visiting species, *Euphoria inda* sometimes covering the entire surface of the liquid in the pails. The Cerambycidæ were likewise often taken in large numbers, *Hypermallus villosus* Fab., and *Elaphidion mucronatum* Say., being most conspicuous. The beetles of the other families were taken in insignificant numbers many perhaps as accidental catches.

Carabidæ.

A surprising number of species of Carabids were taken in bait-pails. The majority of these are rather strong fliers, which probably accounts for their presence in these traps hung on the average of six to seven feet from the ground. Mr. Dietrich's favorite method of collecting carabids is to sink the baits even with the surface of the ground.

The family was well represented by the larger species of the genera Calosoma, Galerita, Elaphrus, Calathus, Platynus, Lebia, Pinacodera, Harpalus, Triplectrus, Tachistodes and Amara. Many of the smaller species were taken principally during the early part of the summer as follows: *Stenocellus tantillus* Dej., from June 7 to July 12; *S. rupestris* Say, from April 6 to May 14; *Stenolophus conjunctus* Say, from May 7 to July 7; *S. ochropezus* Say, *S. fulginosus* Dej. and *S. plebejus* Dej., on May 7; *Selenophorus gagatinus* Dej., from May 10 to May 24; *S. opalinus* Lec., June 24; *Dyschirius globulosus* Say, from May 24 to September 20; *Clivinia bipustulata* Fab., August 23; *Tachistodes partiarius* Say, May 8; *Agonoderus pallipes* Fab., May 14 to 21; *Lebia tricolor* Say, July 3; *Pinacodera limbata* Dej., July 24; *P. platycollis* Say, July 31.

Hydrophilidæ.

This family was represented by only two species, *Helophorus lineatus* Say, taken May 14, and *Sphæridium scarabaeoides* L., captured June 12. The former, because of its aquatic habits, is probably an unusual catch in the bait traps, the latter, however, is known to live in damp places or in decaying vegetation.

Silphidæ.

Occasional catches, chiefly *Necrophorus orbicollis* Say, and *Silpha americana* Linn., were made during the summer. These, no doubt, were attracted by baits that had become old and putrid.

Staphylinidæ.

Staphylinids are known to feed upon fermented sap on the stumps of trees, and it is a wonder to the writers that a larger number of these species were not captured. No doubt if a sieve of a smaller mesh had been used in separating the beetles from the bait, some of the minute species would have been taken. Many of the species are powerful fliers, bringing them into the proximity of the baits that were hung in the trees. They were the first beetles to be trapped in the spring and were taken at intervals during the summer. Several subfamilies were represented, but only single specimens were taken of most of the species. Fifteen specimens of one rare species, *Ephelinus notatus* Lec., were taken on May 17, one on an earlier date, May 7, two on June 2, and five on June 7.

The subfamily Omaliiniæ was represented by three species: *Olophorum obtectum* Er., captured April 26 to May 10; *Arpedium Schwarzi* Fauv., May 3; and *Ephelinus notatus* Lec., as noted above. A single species, *Stenus arculus* Er., of the subfamily Steninæ was taken on July 15. The subfamily Paederinæ was represented by two species; *Hesperobium cribratum* Lec., captured on May 12; and *Lathrobiella rubida* Csy., taken on June 7.

Five species of the subfamily Staphylininæ were taken: *Philonthus umbratilis* Grav., August 30; *P. microphthalmus* Horn, March 17; *Staphylinus mysticus* Er., May 10; and Quedius sp.

The subfamily Tachyporinæ was well represented by a number of genera and species. *Tachinus pallipes* Grav., was taken June 28; *Tachyporus nitidulus* Fab., July 12; *T. scitulus* Er., May 8, at Midvale; Conosoma sp., May 19, at Aspers; *Bolitobius intrusus* Horn, May 19 and June 28, at Aspers; *Mycetoporus consors* Lec., May 10.

The subfamily Aleocharinæ was represented by several species of Atheta taken during the early part of the summer, from March 17 to June 28. Some of this subfamily are very small and probably passed through the sieve or decomposed in the bait.

Histeridæ.

Only a few specimens were taken at intervals; *Hister abbreviatus* Fab., *Hister harrisi* Kby., *Hister americanus* Payk., and *Carcinops quatuordecimstriata* Steph. They were probably attracted by the decomposing bait.

Lampyridæ, Cantharidæ and Melyridæ.

Lampyridæ were rare in baits, a single species *Pyractomena borealis* Rand, was taken July 10. *Cantharus rectus* Melsh., and *C. bilineatus* Say, came to baits in very large numbers during May, June and July, while *C. rotundicollis* Say, was found in smaller numbers, and a single specimen of *Polemius laticornis* Say was taken June 10. A species of Attalus was also taken in baits.

Cleridæ.

A few Cleridæ were taken, but none in abundance. One specimen, *Hydnocera pallipennis* Say, generally considered rare, was taken September 20. The common species *H. unifasciata* Say, was taken on July 19 and 26; *Plœopterus thoracicus* Oliv., June 26 and July 3; and *Enoclerus nigripes* Say, July 7.

Corynetidæ.

Two rare species were taken: *Neichnea laticornis* Say, July 15, and *Cregya oculatus* Say, July 19, and the common species *Phyllobaenus dislocatus* Say, July 31.

Cupesidæ.

The rare species *Cupes concolor* Westw., was taken on August 7.

Mordellidæ and Pyrochroidæ.

Species of the genera Mordella, Mordellistena and Neopyrochora were taken in small numbers during July. All were probably accidental catches.

Anthicidæ.

This family was well represented during the early part of the summer. There was evidence that the beetles had been attracted by the odor of the bait. *Notoxus bicolor* Say, was taken from May 24 to July 5; *Notoxus monodon* Fab., from April 26 to July 5; *Mecynotarsus elegans* Lec., on May 10; *Anthicus cervinus* Laf., April 26 to June 7; *A. vicinus* Laf., from April 26 to June 7; *A. haldemani* Lec., on May 10; and *A. formicarius* Laf., on May 7.

Elateridæ.

The Elateridæ were numerous during June and July, the species of the genus Melonotus being most abundant, namely, *M. communis* Gyll., *M. fissilis* Say., and *M. depressus* Melsh. Species of the genera Aeolus, Athous, Ludius, Hemicrepidius, Hypnoidus, Crigmus, Parallelostethus, Glyphonyx, Dolopius, and Elater were also taken. Several of the species are common visitors of peach trees and are often seen resting upon the foliage. No doubt many of the captures were accidental. The most unusual catch was a single specimen of *Parallelostethus attenuatus* Say., taken May 30.

Melasidæ.

An occasional specimen was taken during July. Three genera were represented, Isorhipis, Microrhagus and Nematodes, the latter yielding two rare species, namely, *M. imperfectus* Lec., taken July 12, and *N. penetrans* Lec. July 26.

Buprestidæ.

The Buprestidæ were only occasional visitors to the baits, and probably accidental catches. Species of the genera Agrilaxia, Chrysobothris, Agrilus and Brachys were taken. *Chrysobothris femorata* Oliv., a species that bores in apple and peach, was taken quite often.

Helodidæ, Dermestidæ and Byrrhidæ.

Occasional catches of representatives of the genera Cyphon, Attagenus and Trogoderma were made. They were probably attracted by decomposing baits after fermentation was completed. One hundred twenty-seven specimens of *T. ornata* Say, were taken from June 7 until August 9. *Cytilus alternatus* Say was captured May 7 and 21.

Nitidulidæ.

This family was most conspicuous in collections from bait pails. This might be expected as the great majority of the species feed on sap or juices of different kinds, especially when they begin to ferment. Representatives of three subfamilies and a large number of species were taken throughout nearly the whole summer and sufficient material was secured in some cases to plot graphs.

The subfamily Carpophilinæ was represented by two genera and eight species. *Colopterus maculatus* Er., was taken continually from May 10 to August 9; *C. truncatus* Rand., from May 10 to August 30. The genus Carpophilus yielded six species; *C. hemipterus* L., taken on July 12 and August 9; *C. niger* Say, on June 7; *C. corticinus* Er., May 10 to July 5; *C. brachypterus* Say., almost continually from July 7 to September 30; *C. antiquus* Melsh., on June 2; *C. nitens* Fall., 1 ♂ June 28, 1 ♂ July 2, 1 ♂ July 15, 1 ♂ July 26, 3 ♂ September 3. The latter species has apparently not been taken since it was described from Mobile, Alabama.

A number of individual captures occurred in the subfamily Nitidulinæ: *Omosita colon* L., taken July 7 and July 15; *Epuræa peltoides* Horn, May 24 to July 19; *Stelidota geminata* Say, abundant from June 21 to August 9; *Lobiopa undulata* Say, on May 24, July 5 and August 23; and *Cychramus adustus* Er., on June 21.

The subfamily Cryptarchinæ was well represented by two genera and five species which came to the bait pails in large numbers throughout the summer. *Cryptarcha ampla* Er., was taken continually from May 10 to July 26; *C. strigata* Fab. From June 2 to August 30; *C. concinna* Melsh., from May 10 to August 30; *Glischrochilus fasciatus* Oliv., from May 8 to August 9; *G. sanguinolentus* Oliv., taken only on May 10; and the rare *G. obtusus* Say, on July 10.

Monotomidæ, Cucujidæ, Erotylidæ, Cryptophagidæ, Phalacridæ, Coccinellidæ, Alleculidæ, Tenebrionidæ, Lagriidæ.

A number of genera and species of these families were captured, all apparently by accident. The genera Europs Catogenus, Laemophloeus, Languria, Tritoma, Henoticus, Acylomus, Stilbus, Hyperaspis, Brachyacantha, Chilocorus, Isomira, Haplandrus and Meracantha were represented. Both eastern species of Statira were taken: *S. gagatina* Melsh. ♀, July 10: and *S. resplendens* Melsh. ♂, July 24.

Melandryidæ.

This family was poorly represented by two species. *Dircaea quadrimaculata* Say, was taken on July 3 and 17, while *Synchroa punctata* Newm., was taken August 2.

Anobiidæ, Bostrichidæ, Cisidæ.

An occasional specimen representing these families was captured, but none were of particular interest. The genera Catorama, Endecatomus, Bostrichus, Xylobiops, and Cis were found.

Scarabaeidæ.

A rather large representation of Scarabs was found in the bait pails. Some of the smaller and stronger flying species as *Aphodius granarius* L., and *A. distinctus* Mull., were taken in considerable numbers during their flight in April and May, while *Ataenius cognatus* Lec., and *Serica vespertina* Gyll., were taken in June and July. Several specimens of *Anomala innuba* Fab., were also taken during July. Six species of Phyllophaga were captured at intervals but not in large numbers. *Cotinis nitida* L., was captured in moderate numbers from July 10 to August 28.

The genus Euphoria, however, came in great numbers and were apparently attracted to the baits. Sufficient material was taken to plot curves for *E. inda*, L., *herbacea* Oliv., and *fulgida* Fab. *E. sepulchralis* Fab., was taken only in moderate numbers during October[5].

[5]It is interesting to note that *E. fulgida* Fab., on different occasions was seen drinking the honey-like secretion that fills the cup-like glands at the base of peach leaves. When the sweet substance runs low, they use one of the sharp spines on the outer angle of the front tibia to lacerate the glands and cause the juice to flow.

Cerambycidæ.

A remarkable number of species were taken considering that the pails were hung in a peach orchard in an open country and distant from any wooded areas. *Hypermallus villosus* Fab., and *Elaphidion mucronatum* Say., were the most conspicuous species, while *Purpuricenus humeralis* Fab., *P. axillaris* Hald., *Ophistomis luteicornis* Fab., and *Strophiona nitens* Forst., were next in numbers. In 1926 *Eburia quadrigeminata* Say., came quite freely during July and August but the following years it was taken only occasionally.

All the species noted by Champlain and Kirk[6] were taken by the writers with the exception of two species in the genera Leptostylus and Gaurotes. In addition the following species were captured: *Pseudibidion unicolor* Rand., July 12; *Brachyleptura rubica* Say., July 24; *Strangalepta lineola* Say., June 18; *Molorchus bimaculatus* Say., May 21; *Phymatodes amoenus* Say., May 24; *P. testaceus* L., June 26; *P. testaceus* var. *variabilis* L., June 6–26; *P. varius* var. *albofasciatus* Bland, June 16; *Cyllene robiniæ* Forst., Oct. 2; *Neoclytus scutellaris* Oliv., Aug. 7; *N. mucronatus* Fab., Aug. 7; *N. acuminatus* Fab., July 17; *Cyrtophorus verrucosus* Oliv., July 15; *Tilloclytus geminatus* Hald., July 15; *Stenosphenus notatus* Oliv., June 24; *Tragidion coquus* L., Aug. 21; *Psenocerus supernotatus* Say., July 15; *Leiopus alpha* Say., June 28; *Lepturges signatus* Lec., July 17; *Hyperplatys maculata* Hald., June 15; and *H. aspersa* Say., July 5–26.

Crysomelidæ.

A large number of species of this family were captured. Many of them, no doubt, were accidental catches, being represented largely by individual specimens.

Curculionidæ.

This family was well represented in numbers of genera and species. The specimens were taken singly and scattered throughout the summer. The following genera were taken: Apion, Phyxelis, Sitona, Phytonomus, Curculio, Elleschus, Madarellus, Apteromechus, Cryptorhynchus, and Hypera.

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[6]Champlain, A. B. and Kirk, H. B. Ent. News 37: 288–291, 1926.

Platystomidæ.

A single specimen of *Brachytarsus sticticus* Boh., was taken July 31.

Scolytidæ.

The attraction of a comparatively large number of scolytids was surprising. Certain species which are usually difficult to obtain, because of their habits, were caught by the baits. Several of the species normally inhabiting pines, oaks and beeches, were taken in baits hung in peach trees some distance from a small wooded area. Their presence in the traps seemed to indicate that they were attracted to the baits. Two species of Ips were captured: *I. avulsus* Eich., June 28; and *I. pini* Say, May 3 and July 19. *Monarthrum fasciatum* Say, was taken frequently from April 20 to September 6 and *M. mali* Fitch, was taken on May 10. *Scolytus rugulosus* Ratz., another common species, was captured from July 5 to August 9, while *S. quadrispinosus* Say, was taken July 10. *Hylastinus obscurus* March was captured during May only; *Xyleborus saxeseni* Ratz., from May 24 to June 15; *Leperisinus aculeatus* Say, April 26 and May 7; *Micracis suturalis* Lec., June 7; and *Anisandrus pyri* Peck, on April 20.

ON THE BIONOMICS OF A PRIMARY PARASITE AND OF TWO HYPERPARASITES OF THE GERANIUM APHID.

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The three parasites discussed in this paper are *Aphelinus jucundus* Gahan, *Aphidencyrtus inquisitor* (Howard) and *Asaphes americana* Girault.* They all belong to the superfamily Chalcidoidea but differ so markedly in every phase of their development that no trouble has been experienced in recognizing each species, no matter in what stage it was found. The first two species mentioned have been under observation at the Insectary of Cornell University during the greater part of the time since September, 1925. Since November, 1926 they have been continuously reared in breeding cages. The observations on *Asaphes americana* cover a much shorter period. Owing to an insufficiency of material, and to the pressure of other work, it was not possible to make as detailed observations on this species as on the other two parasites.

METHODS.

The geranium aphid (*Macrosiphum cornelli* Patch) has proved an ideal host for the breeding of parasites. Unlike many other greenhouse aphids, it is present at all times of year and can be easily propagated.

Considerable difficulty was experienced at first in finding a satisfactory rearing cage. Before any breeding of parasites could be attempted it was necessary to devise some method that would make conditions entirely satisfactory to the aphids. Geraniums are very susceptible to mildew if the plants are kept under too moist conditions. On the other hand, if a geranium gets too dry, the aphids soon become restless and crawl from the plant. Rearing the insects on growing plants,

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The plates were drawn by Elizabeth K. Burckmyer. All of the figures were drawn to the same scale and are about forty times natural size.

*All three parasites were determined through the courtesy of A. B. Gahan, of the U. S. Bureau of Entomology.

therefore, did not seem to be feasible. Leaves of the common Lady Washington geranium (*Pelargonium domesticum*) will keep fresh for days in water and on leaves so kept the aphids were found to thrive perfectly. Although the development of the aphid is somewhat hastened by this method (Griswold, 1927:92) it is not probable that the development of the parasites is abnormally affected.

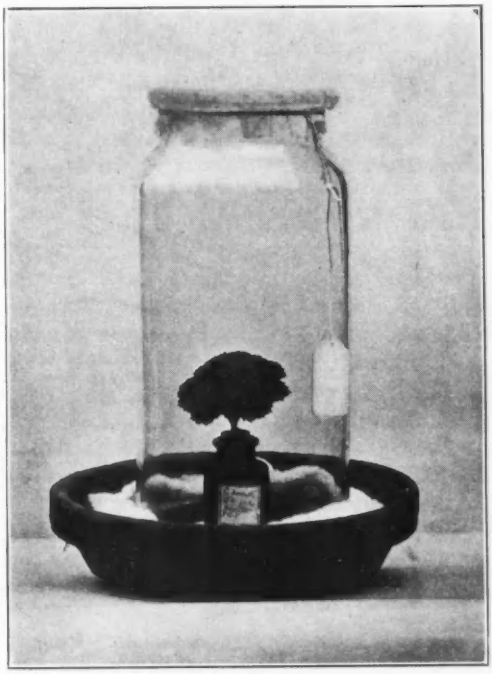

Fig. 1. Cage used for breeding parasites.

The rearing cage which was finally adopted and which has been used in practically all of the work under discussion, is shown in figure 1. Although the glass cylinder comes in close contact with the saucer on which it rests, a strip of cotton batting was kept about the bottom of each cage as an added precaution against the entrance of undesirable animal life. Not only has this cage proved satisfactory to the aphids but it

appears to be equally satisfactory to the parasites which are able to move and to fly about in an almost normal manner. A large supply of aphids, free from parasites, was kept on hand in separate rearing cages.

In working out the life histories, a certain number of parasite-free aphid nymphs, of early instars, were exposed each day to the primary parasite for a period of 24 hours or less. Later these same aphids were exposed to the hyperparasites for another, similar period. By making dissections at stated intervals the stage of development could be ascertained. Knowing the date when the egg of the particular species of parasite must have been laid, it was possible to determine the lengths of the various stages in the life cycle. Of course the rapidity of development depends somewhat upon the temperature, but the data given are those found to prevail under normal greenhouse conditions. In the early part of the present study the periods of exposure were usually 24 hours, but later these periods were reduced to 6 hours, in order to secure more accurate data, especially in regard to the lengths of the egg stages. As soon as the aphids turned black they were removed to small shell vials and carefully labeled.

Dissections of living aphids were made in a drop of normal salt solution (7.5 gr. of sodium chloride to 1000 cc. of water). Minuten nadeln stuck in small wooden handles were found to make ideal needles for dissecting the larvæ of the primary parasite after these had been removed from their host aphids. After the aphids had died and turned black it was found necessary to paste them to a watch glass or depressed slide before dissections could be made and the parasites within removed.

Aphelinus jucundus Gahan.

(Plate I)

Aphelinus jucundus belongs to the family Aphelinidæ. The insect was described by Gahan (1924:8) from specimens reared from the potato aphid. At the Insectary greenhouse this Aphelinus has been commonly reared from the geranium aphid (*Macrosiphum cornelli* Patch) but it has been bred also from the green peach aphid (*Myzus persicae* Sulzer) and from an aphid on rose (*Macrosiphum pseudodirhodum* Patch).* It was

*Determined through the courtesy of Dr. Edith M. Patch, of the Maine Agricultural Experiment Station.

reared also outdoors from an undetermined aphid on cultivated columbine. This chalcid is an internal primary parasite. Its larvæ feed directly on the body contents of the aphids within which they live.

The egg.—The egg is somewhat bean-shaped. Its cephalic end is slightly roughened and more rounded than is the caudal end. The chorion is transparent so that the developing embryo within can be seen. Measurements of 15 eggs gave an average of about 0.26 mm. in length and about 0.07 mm. in width.

The egg is laid in the body fluid of the aphid. The Aphelinus will oviposit in aphids no matter what the stage of development of the latter happens to be, although the younger instars seem to be preferred. As previously stated, early instar nymphs were used in most of the breeding work at the Insectary. It is probable that generally but one egg is laid in a host insect, although in the breeding cages as many as four eggs have been found in a single nearly mature aphid or in one that was fully developed. Hatching occurs in slightly less than three days after the egg has been laid.

The larva.—The first stage larva is pale yellow in color and similar to the egg in form. It is somewhat bean-shaped and is more pointed at the posterior than at the anterior end. By the third day after hatching the larva has straightened out and is somewhat spindle-shaped. By the fourth day, it has filled out considerably and become globular, although it is still slightly pointed at the posterior end. It retains this globular shape through the rest of its larval life. Within ten to twelve days after hatching from the egg, the larva has become full-grown. By this time nothing is left of the aphid but a black, hollow shell. Due to the accumulated fecal matter in the alimentary tract, the body of the parasite is now considerably distended and practically fills that of its host. After the excrement has been voided the Aphelinus elongates and goes into the pupal stage.

The pupa.—When first formed the pupa is yellow throughout. The eyes and the three ocelli soon take on an orange tone and gradually a darkening shows on other parts. When the pupa is fully colored, the thorax is very dark, almost black, while the abdomen remains yellow except for five dark transverse bands on the dorsal surface. The head is greenish yellow as are the antennæ, the wing covers, and the first pair of legs. The second and third pairs of legs are yellow, like the abdomen, while the eyes and the three ocelli are dark reddish brown. When 14 pupæ were measured they were found to average about 1.44 mm. in length and about 0.69 mm. in greatest width.

The orientation of the pupa is exactly the reverse of that of the host insect in the body of which it lies. Not only does the ventral surface of the parasite face the dorsum of the aphid, but the cephalic end of the Aphelinus is at the caudal end of its host. This latter position is occasionally reversed, however, so that the anterior ends of both insects lie in the same direction. The flat black plates of excrement will be found on the dorsal surface of the pupa's abdomen. The duration of the pupal stage is about two weeks.

EMERGENCE.

Aphelinus jucundus reaches maturity about four weeks after the egg has been laid. When ready to emerge, it gnaws a small irregular hole in the body of its host aphid. The opening is made in the dorsal wall and usually between the cornicles. When completed, it extends from the base of one cornicle to the base of the other. Occasionally emergence holes are made at the anterior end of the aphid instead of at the posterior end. In an examination of 107 aphids from which

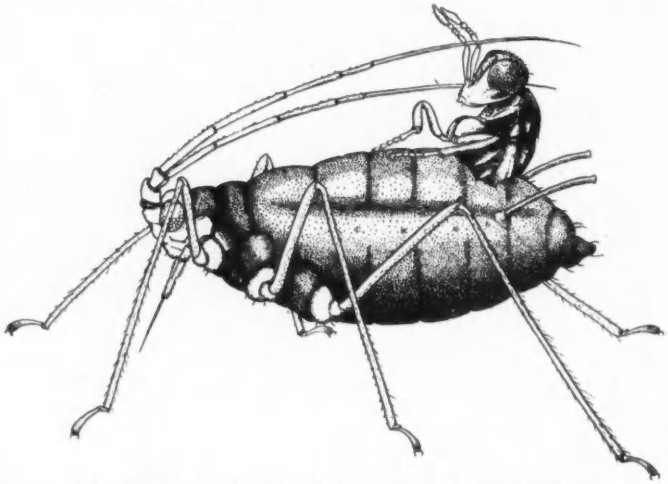

Fig. 2. Adult of *Aphelinus jucundus* Gahan emerging from a late instar nymph of *Macrosiphum cornelli* Patch. Drawn by Elizabeth K. Burckmyer.

adults of the Aphelinus had emerged, it was found that only in a single instance had an exit hole been made at the anterior end of the host. The remaining 106 parasites (99.06%) had emerged through openings made between the cornicles.

When the hole has reached a size sufficient to permit the passage of the chalcid's body, the head is pushed out, then the first pair of legs appears and finally the insect pulls the remainder of its body through the aperture. Knowing the day on which the eggs were laid, and knowing the length of the life cycle, the date of emergence can be determined with reasonable accuracy. By keeping specimens of parasitized aphids where

they can be examined from time to time, chalcids just starting their exit holes may be found without difficulty. In this way it was possible to observe the act of emergence many times. It was possible also to kill specimens in cyanide before they had entirely extricated themselves (Fig. 2). Only a single adult Aphelinus emerged from each aphid.

HABITS.

In some ways *Aphelinus jucundus* is a rather sluggish insect. It is not readily frightened and can be easily picked from a leaf with a camel's hair brush. Or individuals can be caught in a small vial into which they will jump or crawl if the mouth of one is placed near them. When liberated on the laboratory table, they move about in a series of short hops, much like a flea. The insect is a good jumper and, under ordinary circumstances, appears to jump and crawl rather than to fly. It is, nevertheless, perfectly capable of flying when the occasion arises. The parasite is not restricted to definite parts of the greenhouse but has been found wherever the geranium aphid was present.

The oviposition habits of this chalcid are interesting. After examining an aphid with her antennæ, the Aphelinus steps away for a slight distance, turns around, and then backs up to her victim. The ovipositor is thrust out behind and gradually inserted into the aphid. The wings of *Aphelinus jucundus* are rather long and, when at rest, extend beyond the end of the abdomen. Hence they hinder the approach of the parasite as she backs up to her victim. To obviate this difficulty the parasite bends back the tip of her abdomen, thus folding the ends of the wings and holding them out of the way.

Feeding at oviposition holes is a common practice with *Aphelinus jucundus*. As described in an earlier paper (Griswold, 1926:331) the aphids appeared to be paralyzed by this act of the parasite and many never recovered. Further observations have confirmed the opinion previously stated, that many aphids, especially those of the earlier instars, are killed in this manner. In later work, where young aphids were placed on a leaf and exposed to this parasite for 24 to 48 hours, a number of them were always found dead when the leaf was removed from the cage.

THE SEX RATIO.

The male of this species has never been described. As far as could be observed, all of the individuals reared at the Insectary have been produced parthenogenetically and have been females. *Aphelinus jucundus* is therefore thelyotokous.

EFFECT OF PARASITISM ON THE HOST.

The aphid shows no outward signs of having been parasitized until about eight or ten days after the egg of the Aphelinus has been laid. By this time the aphid has become more yellowish in color and the larva of the parasite can be faintly seen through the body wall of its host. Two or three days later, when the contents of the body of the host insect have been almost consumed by the parasite, the aphid gradually turns black, first on the dorsum and finally on the venter. The head, antennæ and legs, however, are pale, practically colorless. Just before this blackening occurs, the aphids are apt to crawl to some secluded spot in the fold of a leaf or under a stipule. In the breeding cages blackened aphids have often been found tucked under the edge of the cage or the bottle holding the geranium leaf, and even in a depression in the cork. The bodies of these blackened aphids appear to be fastened in some manner to the surface on which they rest, for they are not easily removed. Strands or particles of material are usually found on the ventral surface of the aphid's body. It is probable that the parasitic larva secretes some sort of silk for this purpose as described by other writers (Hartley, 1922:229; Wheeler, 1923:25).

PERCENTAGE OF PARASITISM.

The life cycle of the geranium aphid was found to be about ten days (Griswold, 1927:92) while that of the parasite is usually four weeks. For this reason it is very difficult to determine the percentage of parasitism. Yet when one sees the number of blackened aphids in the greenhouse, one realizes that *Aphelinus jucundus* is responsible for killing many plant lice.

Aphidencyrtus inquisitor (Howard).

(Plate II)

This parasite belongs to the family Encyrtidæ. It was described by Howard (1881:367) and, according to Gahan, it has been redescribed several times under different names. A list of the various synonyms appears in a recent paper by Gahan (1927:18). This encyrtid has proved to be an internal secondary parasite. Several efforts were made to rear it from parasite-free aphids, but these efforts met with no success. Furthermore, upon dissecting parasite-free aphids exposed to it, none of its eggs could be found.

The egg.—The egg is oval in outline and slightly more than twice as long as broad. At one end there is a distinct stalk or pedicel. Careful measurements were made of 14 eggs. The average length (not including the pedicel) was found to be about 0.17 mm. and the average greatest width about 0.07 mm. The pedicel was found to vary considerably both in length and in position. In the 14 eggs examined the maximum length of the pedicel was 0.065 mm. and the minimum 0.029 mm. with an average length of about 0.038 mm. In some cases it extended straight out from the end of the egg, while in others it curved or went off at an angle. The egg of this hyperparasite is laid within the body of the larva of the primary parasite which is living within its host aphid. The larva of the primary parasite must have reached a certain stage in its development before the secondary parasite will deposit this egg. *Aphidencyrtus inquisitor* will not oviposit until at least two days after the egg of *Aphelinus jucundus* has hatched. If the temperature in the greenhouse for any reason is lower than usual, so that the development of the primary parasite is retarded, an even longer time must elapse. In the breeding cages two or more Aphidencyrtus eggs have often been laid in the same host. In one instance four eggs were found and in another six, all in a single, well developed Aphelinus larva. Had a greater number of host insects been available it is probable that the eggs of the hyperparasite would have been more widely distributed. The chorion of the egg is transparent so that the developing embryo within can be seen. Just before hatching, the fully formed larva, with a well segmented body, shows distinctly. As the larva is much longer than the egg in which it lies, it assumes a curved position with the cephalic and caudal ends folded back toward the middle part of the body. The duration of the egg stage is about four days.

The larva.—The first stage larva is of the caudate type. During its early larval life the insect is crescent-shaped, but as development progresses, it straightens out somewhat and the tail-like appendage is less pronounced. By the time the larva of the hyperparasite has become full-grown, nothing is left of the primary parasite but the outer body covering. The encyrtid then eats its way out of this host covering and lies directly in the blackened shell of the aphid, the entire inside of

which has already been consumed by the primary parasite. Among the hundreds of dead aphids dissected, three were found each of which contained an Aphidencyrtus larva partly out of the skin of its host parasite, *Aphelinus jucundus*. The larva of the hyperparasite is now more grub-like, although it still tapers somewhat toward the caudal end. After the excrement has been voided, pupation occurs. The length of the larval stage was found to be about twelve days.

The pupa.—At first the entire pupa is pale greenish yellow. Soon, however, the eyes and the three ocelli turn reddish brown and dark areas begin to appear on the dorsum of the thorax and of the abdomen. Finally the whole pupa becomes very dark, almost black, only the wing covers being slightly lighter in color. The average length of 15 pupæ was found to be about 1.1 mm. with an average greatest width of about 0.56 mm. As previously stated, the hyperparasite is now the sole occupant of the blackened shell of the dead aphid. Just as with the Aphelinus, the pupa of the Aphidencyrtus generally lies with its head at the caudal end of the aphid, but, unlike the Aphelinus, the venter of the encyrtid faces the venter of the insect within which it lies. The head capsule of the aphid is filled with the tiny orange ovoid pellets of excrement voided by the Aphidencyrtus. The pupal stage of this secondary parasite is much shorter than is that of the primary. It covers a period of from five to seven days only, thus shortening the life cycle to a period of about three weeks.

Emergence.—The adult emerges through an opening which it gnaws in the body wall of the dead aphid. The hole is smaller than that made by the Aphelinus and its position is not so constant. In the vials in which adults emerged, it was found that generally the hole was made at the posterior end, and that it was more commonly on the dorsum, between the cornicles. However, in many instances such openings were found on the venter. The parasite also occasionally emerges at the anterior end of the aphid. An examination of 201 aphids from which adults of this hyperparasite had emerged showed that 194 (96.5%) of the exit holes had been made at the posterior end. Of these, 116 (57.7% of the total number counted) were found on the dorsum between the cornicles, while 78 were on the venter. Of the 7 openings at the anterior end, 3 were on the dorsum, 2 on the venter and 2 on the lateral surface of the aphid. Had the aphids not been removed from the leaf, or other surface to which they were originally attached, it is probable that all of the emergence holes would have been made on the dorsum. As previously stated, the pupæ of this parasite were rarely found except with the ventral surface toward the venter of the aphid. This means that the Aphidencyrtus

must turn over before it can gnaw a hole in the dorsum of the aphid. Although hundreds of these parasites have been reared in individual vials, in not a single instance have two adults emerged from the same aphid.

Habits.—Aphidencyrtus inquisitor is a much more active insect than is *Aphelinus jucundus*. Both sexes run rapidly and are good flyers. They are also good jumpers but do not move in the series of short hops so characteristic of the Aphelinus. They are easily frightened, and can be caught in a vial only when approached with great caution. Before mating occurs a distinct courtship takes place. When a male is placed in a vial with a female, he may run about for some seconds without becoming aware of her presence. As soon as he discovers her, however, he is all excitement. He runs up and stands in front of her, his body swaying from side to side while he rapidly taps her antennæ with his. Then he stops these attentions and quickly runs around her, returning to his former position. Again his body sways from side to side and again he taps her antennæ with his. Then he stops and runs around her again. These antics may be repeated any number of times. In one instance a little male went through this performance thirty-three different times before copulation took place.

When ready to oviposit, the female mounts the aphid, which she examines with her antennæ. Then the ovipositor is gradually pushed downward and slightly backward into the aphid. The parasite's wings are folded on her abdomen, while her antennæ are held close to her head. While oviposition is going on, the Aphidencyrtus is less easily disturbed than at any other time.

Feeding at oviposition holes is as common a practice with the female of this species as it is with the primary parasite, *Aphelinus jucundus* (Griswold, 1926:331). In this case, however, the habit has no injurious effect on the aphids. After aphids have been placed on a leaf and exposed to this parasite, all of them will generally be found alive when the leaf is removed from the cage.

The sex ratio.—The antennæ of the two sexes are so different that the insects were at first thought to be two distinct species. For this reason, from the very beginning, accurate records

were kept of the number of males and females reared. Of 111 individuals reared from aphids taken at random in the greenhouse, 58% were males and 42% females. Later some careful rearing experiments were carried on with the distinct purpose of determining the sex ratio. Only females that were seen to mate were placed in the rearing cages. From these cages were eventually reared 833 individuals of which 442 (53%) were found to be males and 391 (47%) females. When *Aphidencyrtus inquisitor* reproduces parthenogenetically the species was

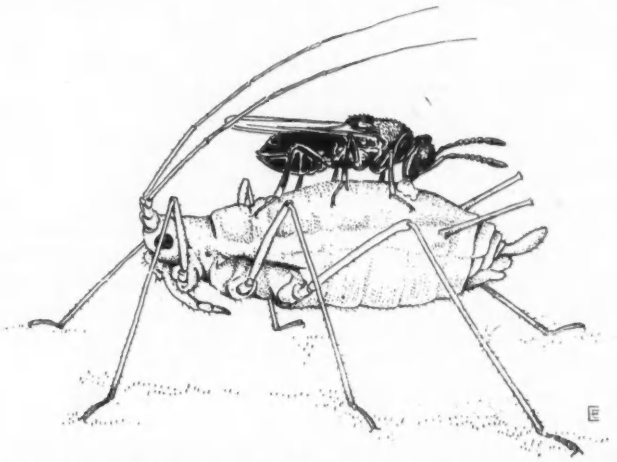

Fig. 3. Female of *Aphidencyrtus inquisitor* (How.) feeding at an oviposition hole made in the abdomen of *Macrosiphum cornelli* Patch. Drawn from living specimens by Ellen Edmonson.

found to be arrhenotokous. In the breeding cages unmated females laid eggs from which were eventually reared 167 individuals, all of which were males.

Percentage of hyperparasitism.—In an effort to get some idea of the percentage of hyperparasitism, 298 blackened aphids were collected at various times at random in the greenhouse and placed in individual vials. From these aphids were eventually reared 257 parasites. Of these, 69% were *Aphelinus jucundus* and 31% were the secondary parasite, *Aphidencyrtus inquisitor*. By destroying Aphelinus larvæ the Aphidencyrtus prevents the increase and spread of a beneficial species of primary parasite.

Asaphes americana Girault.

(Plate III)

This parasite, which was described by Girault (1914:114) belongs to the family Pteromalidæ. It has proved to be both a secondary and a tertiary parasite. In its larval stage it feeds externally on its host when the host is living in the blackened shell of the dead aphid. Its larvæ have been found feeding not only on the larvæ of the primary parasite, *Aphelinus iucundus*, but also on the larvæ and on the pupæ of the secondary parasite, *Aphidencyrtus inquisitor*, when these were lying free in the blackened shells of aphids. As was done with the Aphidencyrtus, an effort was made to rear the Asaphes from parasite-free aphids. This met with no success, nor would this parasite oviposit in parasitized aphids until the latter had turned black.

The egg.—The egg is pearly white in color and oval in outline, although it is somewhat more rounded at the anterior than at the posterior end. Upon measuring 10 eggs they were found to average about 0.25 mm. in length and 0.1 mm. in width. The egg is laid on the outside of the host parasite which is living in its host aphid. Usually the host selected is in the mature larval stage, however, in some instances eggs were found on host pupæ. Generally but one egg is placed on an individual host but in one instance three eggs of *Asaphes americana* were found on a single larva of *Aphelinus jucundus*. Just before hatching, the segmented larva of the Asaphes can be distinctly seen within the egg. The egg stage of this hyperparasite is about four days.

The larva.—The early instar larva is more or less top-shaped, the anterior end being quite blunt while the posterior end tapers somewhat. As development progresses, the caudal end fills out and finally the larva becomes crescent-shaped, thus differing entirely from the larvæ of the other two parasites under discussion. Although the color is yellow, it is of a much paler shade than that of the larvæ of either *Aphelinus jucundus* or *Aphidencyrtus inquisitor*. By the time the larva has become full-grown its host has been consumed, so that the Asaphes remains the sole occupant of the blackened shell of the dead aphid. After the excrement has been voided, pupation occurs. The length of the larval stage in this species is about eleven or twelve days.

The pupa.—The newly formed pupa is pale yellow in color, but soon the eyes become brownish-orange, then the body gradually darkens until it has become almost black. The pupa, like the larva, is crescent-shaped and lies on its side in the body of the dead aphid. About the caudal end will be found the excrement in the form of tiny black ovoid pellets. The length of the pupal stage is about five or six days. Thus the entire life cycle extends over a period of approximately three weeks.

Emergence.—The adult Asaphes emerges from the aphid in a manner similar to that employed by the other two parasites under discussion. The location of the emergence hole is even less constant than in the case of *Aphidencyrtus inquisitor*. This is possibly due to the fact that the Asaphes pupa lies on its side within the dead aphid instead of on its venter, as does the Aphidencyrtus. In an examination of 199 aphids from which adults of *Asaphes americana* had emerged, it was found that 165 (82.9%) had gnawed holes at the posterior end. Of these, 122 (61.3% of the total number counted) were on the dorsum between the cornicles, 25 were on the venter, and 18 on the lateral surface of the aphid. Of the 34 holes made at the anterior end, 27 were on the dorsum and 7 on the venter. As with the other two parasites discussed, only a single adult has been found to emerge from each aphid.

Habits.—*Asaphes americana* was found to be an active insect and a good flyer, but no detailed notes were taken as to its favorite manner of locomotion. In this species there is also a sort of courtship before mating occurs, although it is not as marked as in *Aphidencyrtus inquisitor*. The male jumps on the back of the female and stands there while she walks about. His middle and hind legs rest on her wings, while with his front legs he grasps her eyes. In the breeding cages females with males perched on their backs in the manner just described, were often seen walking about on the geranium leaves, or on the sides of the cage. Actual mating was not observed at the Insectary but Spencer (1926:146) says it "occurs as soon as the female is dry." He also describes in detail the act of oviposition in this species.

The female Asaphes was never seen feeding at puncture holes made by the ovipositor and very probably lacks this habit, which proved to be so common with *Aphelinus jucundus* and with *Aphidencyrtus inquisitor*. Observations made at the Insectary indicated that the female Asaphes was not interested in living aphids, but only in those which were dead, and had turned black. As previously stated, it was in black aphids only in which she was found to deposit her eggs.

The sex ratio.—The two sexes are not as easily differentiated as those of *Aphidencyrtus inquisitor*. The abdomen of the female Asaphes is more pointed than is that of the male, and the ovipositor can be plainly seen on the ventral surface.

There is also a slight difference in the antennæ. The males of this species are more prevalent than are the females and this condition made the breeding work difficult. Of 40 individuals reared from parasitized aphids taken at random from the greenhouse, 72.5% were males and 27.5% were females. An attempt was made to carry on some rearing experiments to determine the sex ratio in *Asaphes americana*. As previously explained, mating was not observed in this species but the preliminary courtship was a common occurrence. Only couples which were seen to engage in this courtship were admitted to the breeding cages, and then only after they had remained together for some hours in the vials in which the courtship had taken place. From these breeding cages were reared 193 individuals, of which 158 (82%) were males and 35 (18%) were females. This species also reproduces parthenogenetically and was found to be arrhenotokous. Eggs laid by unmated females produced 79 males and no females.

Percentage of hyperparasitism.—No studies were made on the percentage of hyperparasitism in *Asaphes americana*. As this species was found to be both a secondary and a tertiary parasite, it must be considered both a beneficial and an injurious insect, depending upon the status of the host attacked. According to Muesebeck and Dohanian (1927:4) "it is doubtful if any species are obligatory tertiary parasites." It has been proved by these studies that *Asaphes americana* is not such a parasite.

CONCLUSIONS.

As one studies parasites—primary, secondary, tertiary—one wonders if the end of parasitism is ever reached. Surely *Asaphes americana* must have its parasitic enemies, while these in turn must have theirs. As long as the blackened shell of the dead aphid remains intact, why should this not serve as a home for one parasitic larva after another, each of which devours its predecessor only in turn to be itself devoured? This may all be true but it would be difficult to prove.

SUMMARY.

Aphelinus jucundus is an internal primary parasite, *Aphidencyrtus inquisitor* is an internal secondary parasite, while *Asaphes americana* is both an external secondary parasite and an external tertiary parasite.

The egg, larval, and pupal stages of all three chalcids are spent within an aphid which is the true host of the Aphelinus only. As they differ in every phase of their development, no trouble was experienced in recognizing each species no matter in what stage it was found.

The adult of each of the three species emerges through a hole gnawed in the body wall of the dead aphid. The hole is more commonly on the dorsal surface, between the cornicles.

With both of the hyperparasites there is a preliminary courtship before mating occurs.

Feeding at oviposition holes is a common practice with *Aphelinus jucundus* and with *Aphidencyrtus inquisitor* but not with *Asaphes americana*.

Aphelinus jucundus appears to reproduce by parthenogenesis only, all of the progeny being females. *Aphidencyrtus inquisitor* reproduces both sexually and parthenogenetically. With sexual reproduction, males are slightly more common than are females. The progeny of unmated females are all males. In *Asaphes americana*, males are much more common than are females, while unmated females were found to produce only males.

The life cycle of *Aphelinus jucundus* is four weeks while that of the aphid is ten days. This lack of adjustment of the parasite to its host makes it difficult to determine the percentage of parasitism. Both *Aphidencyrtus inquisitor* and *Asaphes americana* have life cycles of about three weeks. Therefore the hyperparasites are better adjusted to their hosts than is the primary parasite to its host aphid.

Aphelinus jucundus is a beneficial parasite while *Aphidencyrtus inquisitor* is an injurious one. *Asaphes americana* is either beneficial or injurious, depending upon the status of its host.

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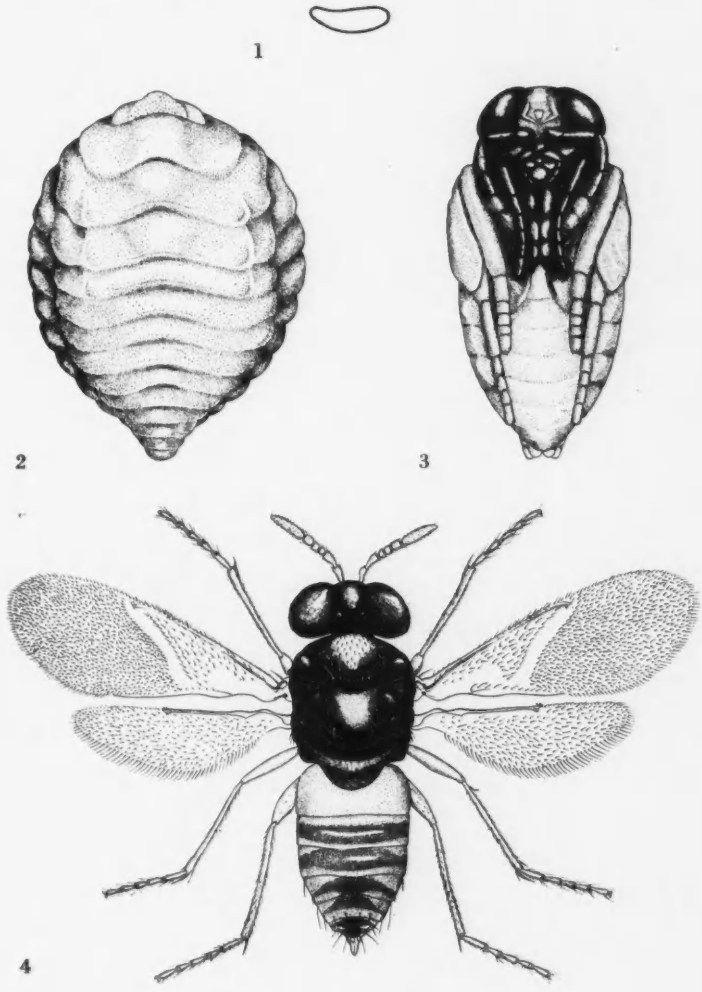
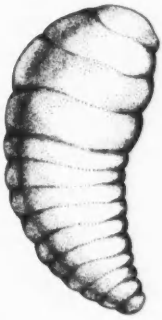


Aphelinus jucundus Gahan.

Fig. 1, Egg; Fig. 2, Mature larva, Fig. 3, Pupa, ventral view; Fig. 4, adult female.

1



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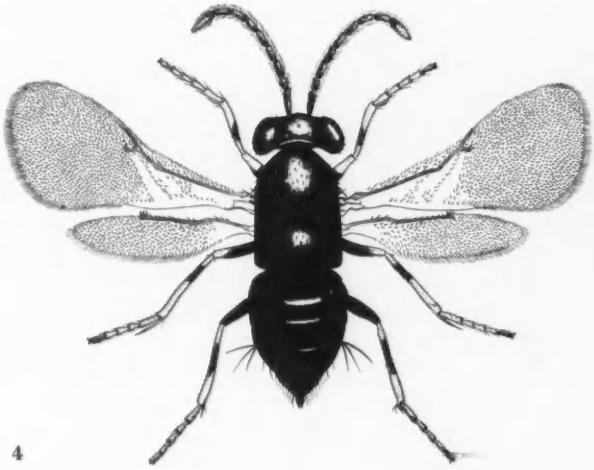
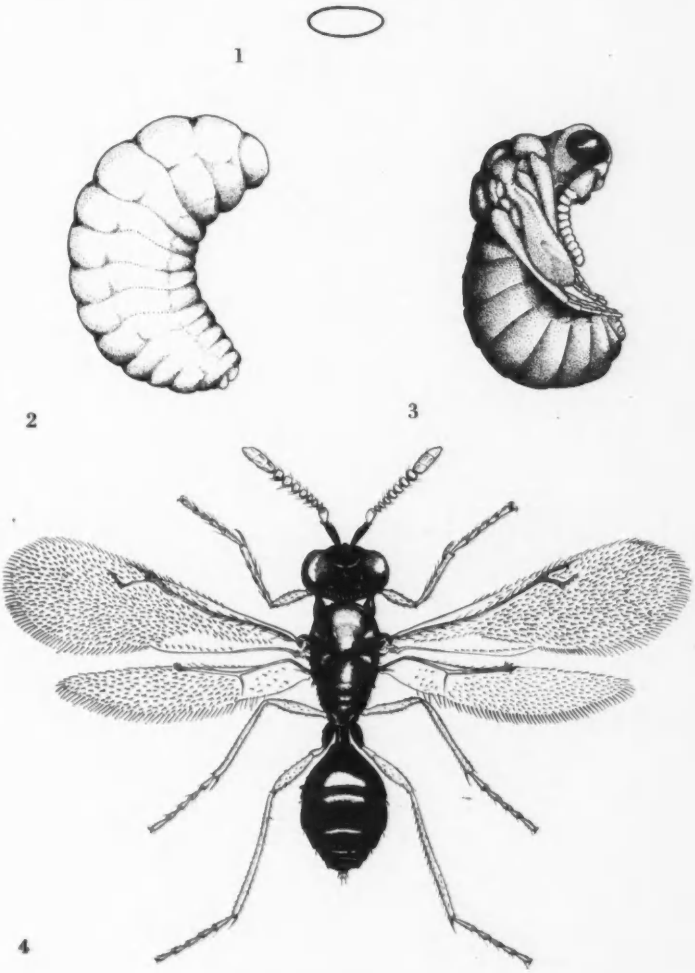


4

Aphidencyrtus inquisitor (How.)

Fig. 1, Egg; Fig. 2, Mature larva, lateral view; Fig. 3, Pupa, ventral view; Fig. 4 Adult male.



Asaphes americana Girault.

Fig. 1, Egg; Fig. 2, Mature larva, lateral view; Fig. 3, Pupa, lateral view; Fig. 4, Adult male.

NOTES ON THE NATURAL ENEMIES OF THE IRIS BORER, MACRONOCTUA ONUSTA GROTE (LEPIDOPTERA).

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Little is known concerning the natural enemies of the Iris borer, *Macronoctua onusta* Grote. Dietz (1) records two species of Hymenoptera that were found to be parasitic on the larvæ of this pest, and his record seems to be the only one that has been made. As several entomologists and the Iris growers themselves are interested in the biological control of the borer, the writer has been urged to record some observations he has made on its natural enemies. An unusually heavy infestation of the Iris borer of several years standing was under observation. Evidence is at hand to show that the caterpillars are attacked by a number of predaceous and parasitic insects, and that they are further reduced in numbers by insectivorous birds and rodents. The relations between the habits of this insect and its enemies will be more clearly understood if a brief résumé of its seasonal activities is presented.

Macronoctua onusta has but one generation a year, winter being passed in the egg stage. The moths emerge in late summer and soon begin depositing their eggs. The eggs are inserted in folds and crevices that occur in either the dead and discolored remains of the Iris plants or in those of other plants which may be present in the immediate vicinity. With the coming of warm weather in the spring, the eggs hatch and the young caterpillars seek the tender foliage of the host plant where they begin leaf-mining activities. At this early stage they will often abandon their burrows and wander about over the leaves. As development proceeds, the leaves, especially their edges, will be made quite ragged by the internal feeding of the caterpillars. Their activities soon take them down among the ensheathing lower halves of the leaves where they remain until nearly half grown before attacking the rhizomes. Often instead of penetrating the heart of the rhizome the caterpillar will eat out a deep channel along its side. Many of the caterpillers were observed to go from one rhizome to the next, and

often would severely injure if not destroy several before reaching maturity. It will be seen that the activities of the caterpillars may contribute to their being parasitized by such flies as the Sarcophagids and Tachinids.

The caterpillars are gross feeders and produce a large amount of wet excrement which accumulates in the burrows. Such an accumulation furnishes an excellent medium in which numerous organisms are sure to develop. Bacteria and fungi become active and help produce evil smelling products of decay. Dipterous larvæ were noted to be present in numbers. Doubtless the majority of these were scavangers, but such conditions would aid larvæ with habits such as those of *Muscina stabulans* to reach the caterpillars in whose bodies they are able to live as parasites.

Early in August, when larval development was nearing completion and pupation had begun, one hundred caterpillars of *Macronoctua onusta* were collected and placed in breeding cages. Care was exercised to avoid injuring the specimens. Three or four inches of clean moist sand had been lightly packed in the bottom of each cage, and in this the caterpillars were able to construct their pupal chambers much as they do in the earth near the host plant. The cages were left outside and developments watched with interest, as a census of the species that might be parasitic on the caterpillars was much desired.

DIPTERA.

The first Diptera appeared on September 1 and the last on September 10, the first moths emerging on the latter date. There was an indicated parasitism of ten per cent. In each instance the host had apparently been destroyed just before pupation, the puparium of the fly lying in the sand in the immediate vicinity. The following species issued from the caterpillars of *Macronoctua onusta: Muscina stabulans* Fall., *M. assimilis* Fall., *Myiospila meditabunda* Fab. (Muscidæ); *Sarcophaga cimbicis* Tns., *S. latisterna* Park. (Sarcophagidæ); and *Masicera senilis* Mg. (Tachinidæ). This opportunity is taken for thanking Dr. J. M. Aldrich, of the U. S. National Museum, for his services in making known the identity of the Diptera.

For the purpose of indicating to what extent each species may be considered a natural enemy of *Macronoctua onusta*, the following citations are presented.

Muscina stabulans Fall.

More specimens of *Muscina stabulans* were secured than of any other Diptera. A review of the literature reveals that the larvæ of *M. stabulans* are nearly omnivorous, that they are predaceous, and that they do become parasitic. Portchinsky (6) found that the larvæ are predaceous on those of other Muscids and grow very quickly on this live diet, that they are not cannibalistic, and that they are scavengers, living in decaying animal and vegetable matter. When he fed them fresh dead flies and other insects they bored into the bodies and ate the contents. Graham-Smith (2) also found them to be predaceous on the larvæ of other Diptera. He observed that the larvæ, especially in the later stages, tend to migrate, even though the food supply is abundant. Herold (3) bred *M. stabulans* from *Euxoa segetum* Schiff. and mentions that prior to this no Diptera had been bred from this host. Rodionov (7) bred *M. stabulans* from pupæ of the corn ear-worm, *Heliothis obsoleta* Fab.

Muscina assimilis Fall.

The larvæ of this fly are very similar in habits to those of *M. stabulans*. Keilin (4) describes them as semi-carnivorous or omnivorous, as they can maintain life in the absence of animal matter upon vegetable matter in a state of decomposition. He states that they are frequently found in decaying fungi and other vegetable matter, where they live upon the larvæ of such Diptera as *Drosophila confusa*, *Fannia canicularis* L., and *Aphiochaeta rufipes* Mg.

Myiospila meditabunda Fab.

The habits of the larvæ of this species resemble the former in many respects. Portchinsky noted that they are cannibalistic when other food is scarce. Keilin found them to be carnivorous, feeding on the larvæ of Sarcophagids as well as those of certain Anthomyiids and Borborids which accompanied them.

Sarcophaga cimbicis Tns.

The Sarcophagids are well known parasites of other insects. The known hosts of *Sarcophaga cimbicis* are from such diverse orders as the Orthoptera, Coleoptera, and Lepidoptera, and

include the Grasshoppers, the *Phyllophaga*, the green clover worm, *Plathypena scabra* Fab., and the cankerworm, *Alsophila pometaria* Harr.

Sarcophaga latisterna Park.

Sarcophaga latisterna has been recorded as a parasite of several Lepidoptera. It seems to be more selective in the choice of hosts, apparently confining itself to the one order. Some of the known hosts are *Heliothis obsoleta*, *Alsophila pometaria*, and the cabbage butterfly, *Pieris rapæ* L.

Masicera senilis Mg.

Specimens of this species made their appearances on September 9 and 10. All other Diptera had emerged on September 1. In point of numbers appearing it ranks next to *M. stabulans*. Thompson, W. R. and Thompson, M. C. (8) in a paper dealing with the taxonomy and biology of *Masicera senilis* state that "it seems probable that *myoidea-* or *radicis-* is taxonomically identical with *senilis*, although biologically the two forms may perhaps be distinct." In Southwestern France, *M. senilis* has two generations a year and is in both generations a parasite of the European corn borer, *Pyrausta nubilalis* Hubn. The period of hibernation is passed in the second larval stage in the hibernating caterpillars of the host. Thompson and Parker (9) found that in the laboratory the larvæ of *M. senelis* were deposited on the leaves on which the young caterpillars of the host were feeding, and that the parasite larvæ, instead of lying in wait for their hosts, started out in search of them. The American homonym seems to be a common parasite of Lepidopterous stem borers. Lowry (5) states that *M. senilis* was by far the commonest parasite bred from larvæ of the common stalk borer, *Papaipema nebris* Gn. during the three years of his study of that pest in New Hampshire and accounted for over half of the parasitism.

HYMENOPTERA.

No Hymenoptera issued from the caterpillars under observation. Dietz reports two species, *Apanteles militaris* Walsh. (*Braconidæ*) and *Amblyteles jucundus* Brulle (Ichneumonidæ) as being parasitic on *M. onusta* in Indiana. *Apanteles militaris* is known as a gregarious parasite of the army worm, *Cirphis*

unipuncta Haw., and *Amblyteles jucundus* is known to be parasitic on *Papaipema* larvæ.

PREDACEOUS COLEOPTERA.

Both the larval and adult stages of *Calosoma* were encountered while conducting these investigations. *Calosoma calidum* Fab. was most frequently seen. While *Calosoma* larvæ were not observed to attack the caterpillars of *M. onusta* in the field they did not hesitate to do so in captivity.

BIRDS.

On one of the visits to the Iris plantings the writer and a nursery inspector saw a female robin, *Planesticus migratorius migratorius* L., collecting caterpillars from near the infested plants. As it was possible to approach to within a short distance of the bird we were able to convince ourselves that the caterpillars were those of *M. onusta*. A recent cultivation may have disturbed the borers and made their discovery the easier.

RODENTS.

Shortly after pupation had begun it was observed that some small insectivorous rodents had discovered the larvæ and pupæ present in numbers and were making the Iris plantings their feeding grounds. A rain early the night before tended to obliterate disturbances in the earth's surface and made the recent diggings of the little mammals the more conspicuous. That they were after larvæ and pupæ was quite obvious, for many times their excavations revealed opened pupal chambers from which the occupants had been extracted.

SUMMARY.

1. An unusually heavy infestation of the Iris borer of several years standing was under observation.

2. The following Diptera were bred from caterpillars of *M. onusta: Muscina stabulans* Fall., *M. assimilis* Fall., *Myiospila meditabunda* Fab., *Sarcophaga cimbicis* Tns., *S. latisterna* Park., and *Masicera senilis* Mg.

3. There was an indicated parasitism from Diptera in 1928 of ten per cent.

4. In number of individuals appearing *Muscina stabulans* ranked first and *Masicera senilis* second.

5. The host had apparently been destroyed in each instance just before pupation, the puparium of the fly lying in the immediate vicinity of the pupal chamber.

6. The leaf feeding activities of the young caterpillars may contribute to their being parasitized by the larvæ of *Masicera senilis*.

7. The filthy conditions under which the caterpillars live obviously contribute to their being parasitised by larvæ with habits such as those of *Muscina stabulans*.

8. The activities of the caterpillars expose them to the attacks of such parasitic Diptera as the Sarcophagids.

9. No Hymenoptera issued from the caterpillars under observation.

10. Predatory enemies of *Macronoctua onusta* include the larval and adult stages of *Calosoma*, of which *C. calidum* Fab. was the most common; the robin, *Planesticus migratorius migratorius* L.; and insectivorous rodents.

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A NEW GENUS AND THREE NEW SPECIES OF SOUTH AMERICAN CICADELLIDÆ (HOMOPTERA).

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Ohio State University.

The species described below are so distinct from other Cicadellidæ and form as a group so well marked an assemblage that I feel warranted in placing them in a new genus. Types of new species in the author's collection.

Genus **Idiotettix.**

The shape of Idiocerus but with ocelli well up on the border between vertex and front, with some resemblance to Cicadella of the short vertex forms. Head very broad; eyes conspicuous extending distinctly beyond borders of pronotum; vertex short, scarcely as long at middle as next the eye; front broad, nearly as wide as long; clypeus expanding toward the apex; pronotum strongly arched in front, lateral border short; scutellum large; elytra elongate, extending beyond tip of abdomen, narrowing to the apex with a distinct appendix; veins rather obscure; clavus without cross nerves.

Type of the genus, *Thamnotettix magnificus* Osb.

Idiotettix magnificus Osb.

Thamnotettix magnificus Osborn. Annals of the Carnegie Museum, Vol. XV, 1924, p. 424.

The type specimen was a female from Quatro Ojos, Bolivia, in the Carnegie Museum collection. A male from the author's collection which agrees in all general characters with the female has the last ventral segment short, scarcely as long as the preceding, valve hidden or wanting; the plates apparently fused at base, apical two-thirds bearing short stiff bristles and the apex narrowed, acute, upturned and reaching end of pygofer.

The colors are possibly slightly darker, but correspond in picture with the female as described. The female is 12 mm.; male 9.5 mm. in length. The male was collected by H. S. Parish, Bartica, British Guiana, March 20–30, 1901. This species was doubtfully referred to the genus Thamnotettix with the note that it bore a strong resemblance to some members

of the genus Cicadella. Since the publication of that description, I have received specimens of three other species which, taken together, form a group which seem to me to warrant the forming of a new genus. Their exact affinities seem still problematic, since they possess features which taken by themselves might connect them with Idiocerus, Cicadella or perhaps more pronouncedly with Thamnotettix, although they do not agree well with any group within any one of these genera. The position of ocelli will exclude them from either Bythoscopinæ or Cicadellinæ and place them in Jassinæ, but in size and elytral patterns they seem rather to belong to Cicadella than to Thamnotettix.

Idiotettix boliviana n. sp.

Head broad, much wider than pronotum, eyes almost protruding; vertex very short, scarcely as long at middle as next the eye: ocelli on the border between vertex and front, much nearer to the eye than to each other, about twice the diameter from the eye; front longer than wide, borders curving towards base of clypeus; clypeus twice as long as width at base, widening toward tip; loræ elongate. Pronotum polished, faintly rugose, lateral border reduced to a point, lateral angles broadly rounded, hind border slightly concave.

Vertex with a broad orange red band behind the ocelli and another below the ocelli on base of front which has, lower down, two broad browish cross bands. A line between the ocelli is luteus and two bands, and the apex on front are pale yellowish; the antennal pits and a broad line on suture between front and cheek jet black; clypeus and loræ pale yellowish, slightly tinted with brownish on the central part; pronotum, scutellum, and elytra mostly brown, tinged with reddish or chocolate. A row of spots next to commisure and the claval suture at base and toward tip milky hyaline. Along center of elytra and apical areoles mostly yellow, base of outer cell with three spots on the central apex, reddish. Beneath dull yellowish, with spot on the propleura and sternum and the tarsi, black or brownish.

Described from a single specimen (holotype), Coroico, Bolivia, received from a European dealer.

Idiotettix fasciatus n. sp.

Head broad, distinctly wider than pronotum; vertex short, margins nearly parallel; ocelli less than twice their diameter from the eye; front long, slightly convex; clypeus twice as long as wide; loræ elliptical almost touching margin of cheek. Pronotum short, hind border slightly concave; scutellum smaller than in ***boliviana;*** apex acute; clavus with two distinct veins, the anterior one quite short.

General color fulvous, a broad fulvous band above and below ocelli and two stripes tapering toward apex on the front; front dull yellowish with nine or ten dark lateral arcs; pronotum with four broad longitudinal stripes and the border fulvous; scutellum brown on the disk with a V-shaped black mark margined by yellowish, the lateral borders fulvous; elytra brown fulvous with a velvety texture, with claval and discal veins of elytra dark purplish margined with blackish; outer half of elytra with five irregularly shaped whitish spots margined with fuscous, apical areas fuscous, center of tip and part of apical veins whitish; beneath pale yellow, tips of tarsi dark. Length 8 mm.

Described from two specimens, one (holotype), Hohenau, and the other (allotype), Villarica, Paraguay. These are slightly smaller than *boliviana* and differ from that species very distinctly in the conspicuous stripes of the pronotum.

Idiotettix brunneus n. sp.

Head distinctly wider than pronotum, vertex short considerably shorter at middle than next the eye, ocelli near the eye, scarcely more than the diameter from the margin; front long, tapering with slight curvature to base of clypeus; clypeus more than twice as long as width at base, apex rounded; loræ elongate, the outer margin paralleling very closely the margin of the narrow cheek. Pronotum short, lateral angles broadly rounded, hind border scarcely concave; scutellum wider than long; elytral veins fairly distinct. Color uniformly brown with arcs, on the front, faint stripes on the pronotum, the elytral veins and borders to faintly defined milky spot on outer half of elytra, fuscous. Length 7 mm.

Described from a single specimen (holotype) received from a European dealer and labeled Hohenau, Paraguay.

FIVE NEW APHIDIDÆ FROM COLORADO.

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This paper deals with four new species of the subtribe *Macrosiphina* and one of the subtribe *Aphidina*.

Acknowledgments are due to Dr. P. W. Mason for examination and opinions concerning these forms.

Macrosiphum williamsi, n. sp.*

Apterous summer viviparous female.—(Plate I, Fig. 1; Plate II, Figs. 1, 3 and 4). Described from type and 6 paratypes taken on *Lactuca* sp. in foothills near Fort Collins, Colo., May 30, 1916, by L. C. Bragg.

Color: Brick-red, shining, becoming lighter on pronotum, head and terminal body segment; cauda pale yellow; legs pale yellowish except knees, distal ends of femora and tibiæ and entire tarsi, which are dusky to black; antennæ dusky except base of joint III, which is pale; cornicles black.

Measurements: Body to base of cauda, 2.50 mm. when alive (2 mm. after being mounted); hind tibiæ 1.70 mm. (1.66 to 2 mm.); antennæ 2.70 mm. (2.50 to 3 mm.); joints: III, 1.08 mm. (1 to 1.12 mm.); IV, .33 mm. (.32 to .38 mm.); V, .30 mm. (.30 to .33 mm.); VI, .10 mm. + .80 mm. (.75 to .80 mm.); cornicles, .50 mm. (.45 to .50 mm.); cauda, .40 mm.†

Structural characters: Secondary sensoria on joint III only, about 71 in number; hairs on body blunt or slightly capitate, short, .04 mm. in length and sparse; on cauda slightly curved, pointed, .08 mm. long and 6 or 7 on a side; on legs blunt, .04 mm. long and moderately numerous; on antennæ slightly capitate, barely attaining diameter of joint in length; cornicles cylindrical or slightly tapering, with closed reticulations on distal one-fourth, remainder imbricated, distinct flange present; cauda acute conical with slight constriction near base; frontal tubercles distinct and diverging; lateral tubercles not evident; ocular tubercles present.

Alate viviparous female.—(Plate I, Fig. 2; Plate II, Fig. 2). Described from type and 11 paratypes taken on *Lactuca* sp. in foothills near Fort Collins, Colorado, May 30, 1916, also 7 other paratypes taken June 2, 1916, all by L. C. Bragg.

Color: Brick-red on abdomen, lighter on thorax and head; cauda pale yellow; legs pale yellow except knees, distal ends of femora and

*Measurements in parentheses refer to range of variation in paratypes.

†Measurements of caudæ include both hard and soft portions.

tibiæ and entire tarsi black; antennæ dusky throughout; cornicles black; stigmas brownish-yellow.

Measurements: Body, to base of cauda, 2.17 mm. alive (2 mm. in balsam mount); hind tibiæ, 2 mm. (1.70 to 2 mm.); antennæ, 2 mm.; joints as follows: III, 1.34 mm. (1.10 to 1.35 mm.); IV, .36 mm. (.33 to .42 mm.); V, .38 mm. (.30 to .40 mm.); VI, .12 + .93 mm. (.76 to .93 mm.); cornicles, .50 mm. (.43 to .52 mm.); cauda, .30 mm.

Structural characters: Secondary sensoria on joint III, 91; IV, 2 on one antenna and 6 on the other (2 to 6); other joints without secondary sensoria; hairs blunt or slightly capitate, on body .03 or .04 mm. in length, rather sparse; on antennæ similar; on legs similar or slightly longer and more numerous; on cauda pointed and somewhat curved, 5 or 6 on a side; cornicles cylindrical, slightly broader at base, with closed reticulations on distal one-fourth with distinct flange; cauda acute, with slight constriction near base; frontal tubercles distinct and diverging; fore wings with mediæ twice branched; hind wings with both cross veins present.

Collections were taken from *Lactuca* sp. in foothills near Fort Collins, Colorado, Altitude 6,000 to 7,000 feet, by L. C. Bragg, as follows:

Apterous viviparous female.—Two collections, May 30 and July 6.*
Alate viviparous female.—Two collections, May 30 and June 2.

Types in United States National Museum, (Slides No. 41924); paratypes in collection of Colorado Agricultural Experiment Station.

This species is very close to *Siphonophora muralis* Buckton, but differs from Buckton's description in following cornicle measurements: For *muralis*, 1.27 mm. in apterous and .76 mm. in alate viviparæ, as compared with .50 mm. in both apterous and alate viviparæ in *williamsi*. According to Theobald's description† sensoria differ as follows on third joint of antennæ for *muralis*, 25 to 28 in apterous and 30 to 35 in alate as compared with 71 in apterous and 91 in alate of *williamsi*.

The species is named after T. A. Williams, who first described it, though under the name of *Siphonophora muralis* Buckton.‡

This species seems to closely resemble *Macrosiphum sonchi* L. It seems to differ in that *sonchi* seems to have considerably fewer sensoria on antennal joint III and none on joint IV in alate; cornicles are more long and slender. The food plant seems also to differ as *sonchi*, though reported from quite a number of hosts, is apparently not recorded from wild *Lactuca*.

*A collection of apterous viviparæ belonging to this species was taken at Newton, Kansas, October 11, 1914, by the Senior author.

†Theobald, F. V., The *Aphididæ* of Great Britain, 1: 93.

‡Williams, T. A., The *Aphididæ* of Nebraska, Apr. 1910, 83. (Univ. Studies, 10 :2, 83). See also Davis, J. J. Williams, "The *Aphididæ* of Nebraska;" A Critical Review (Univ. Studies, Lincoln, Nebraska, 11: 3, p. 31, 1911).

This species may seem to bear a resemblance to *Macrosiphum lanceolatum* Patch on *Solidago*, especially in regard to color, but it differs decidedly in the ratio of antennal joints ("45, 38, 35, 10 + 55" in Patch's species, and 100, 32, 32, 11 + 75 in ours), and in the number of sensoria on joint III (alate viviparæ 30, and apterous viviparæ 20 in Patch's, and 91 in alatæ and 71 in apteræ in our species).

Myzus leucocrini n. sp.

Apterous summer viviparous female.—(Plate I, Fig. 3; Plate II, Figs 5 and 6). Described from type and 16 paratypes taken on *Leucocrinum montanum*, near Fort Collins, Colorado, May 26, 1916, 9 others from May 6 to May 19, all by L. C. Bragg.

Color: Immature and freshly matured individuals are light green with a conspicuous rusty blotch about the base of each cornicle; cornicles pale on proximal half and blackish on distal half. Old adults appear black or very dark green or greenish-brown with tip of abdomen pale greenish and with rusty coloration at bases of cornicles; cauda pale yellowish; legs very pale, except for distal two-thirds of femora, which are slightly dusky, and tarsi and tips of tibiæ, which are black; antennæ are slightly dusky except base of joint IV and almost entire III, which are very pale; cornicles dusky, especially distally.

Measurements: Body to base of cauda, 1.75 mm.; hind tibiæ, 1 mm.; antennæ, 1.60 mm.; joints as follows: III, .38 mm. (.33 to .40 mm.); IV, .28 mm. (.24 to .29 mm.); V, .25 mm. (.24 to .30 mm.); VI, .12 mm. to .36 mm. (.34 to .41 mm.); cornicles, .40 mm.; cauda, .15 mm.

Structural characters: Secondary sensoria absent on antennæ; hairs blunt, minute, on body practically invisible; on antennæ, hardly .01 mm. in length, and sparse; on tibiæ similar, but slightly longer, over .01 mm., more pronounced on the inner margin; on cauda pointed, curved and about .04 mm. long, and about 5 on a side; cornicles peculiar in shape, outer margin slightly curved inward, inner side curving from a broader base to form more slender middle portion, then curving to form slight swelling at distal end, flange distinct, cornicle imbricated; cauda blunt, almost parallel sided, with slight constriction near base; frontal tubercles pronounced, with tendency to convergence; ocular tubercles present; surface of body marked with reticulations which are distinct though not frosted.

Alate viviparous female.—(Plate I, Fig. 4; Plate II, Figs. 7, 8 and 9). Described from type and numerous paratypes taken on *Leucocrinum montanum* near Fort Collins, Colorado, May 6 to 28, 1916, by L. C. Bragg.

Color: Abdomen, head and pronotum light green, meso- and metathorax black, head and pronotum tinged with dusky, abdomen with lateral spots and dorsal dashes of dusky or dark green; areas at bases of cornicles tinged with orange; antennæ, legs and cornicles pale to color-

less, except tarsi, tips of tibiæ, cornicles and antennal joints III, IV, and V, and entire VI dusky to black; in older examples entire cornicles and tibiæ are entirely black or blackish; cauda pale greenish or slightly dusky; stigmas yellowish-brown; veins of fore and hind wings narrowly bordered with brownish to black.

Measurements: Body, 1.60 mm. to base of cauda; hind tibiæ, .83 mm.; antennæ, 1.60 mm.; joints as follows: III, .37 mm. (.34 to .40 mm.); IV, .28 mm. (.26 to .30 mm.); V, .26 mm. (.25 to .29 mm.); VI, .12 mm. + .41 mm. (.41 to .47 mm.); cornicles, .26 mm. (.25 to .38 mm.); cauda, .12 mm.

Structural characters: Secondary sensoria on joint III only, 8 and 9 in number (6 to 11); all joints heavily imbricated; hairs, cauda, and cornicles as in apterous viviparæ; fore wings with mediæ twice forked; hind wings with 2 cross veins.

Collections were taken on *Leucocrinum montanum*, at Fort Collins, Colorado, by L. C. Bragg, as follows:

Apterous summer viviparous female.—Four collections, May 6 to 26.
Alate viviparous female.—Five collections, May 4 to 28.

Types in collection of United States National Museum (Slides No. 41921); paratypes in collection of Colorado Agricultural Experiment Station.

This species is peculiar in the wide variation of color exhibited from the light green examples to the nearly black ones. This is likely to give the impression of two species in a colony.

Myzus polemonii n. sp.

Apterous summer viviparous female.—(Plate II, Figs. 10 and 13). Described from type taken on *Polemonium* sp. in Cherokee Park, Colorado, September 20, 1915, by L. C. Bragg.

Color: Impossible to determine, as specimen was not observed before being placed in balsam.

Measurements: Body, to base of cauda, 3 mm.; hind tibiæ, 2 mm.; antennæ, 2.90 mm.; joints as follows: III, .78 mm.; IV, .38 mm.; V, .41 mm.; VI, .12 mm. + .80 mm.; cornicles, .80 mm.; cauda, .28 mm.

Structural characters: Secondary sensoria on joint III only, 30 in number; hairs slightly capitate on body, .05 to .06 mm. long, fairly numerous; on antennæ similar but slightly shorter; on legs similar but more numerous; on cauda pointed, curved, .08 mm. long, 2 on each side and 1 on dorsal side; cornicles cylindrical, faintly imbricated at distal end; cauda bluntly conical; frontal tubercles distinct and somewhat converging; ocular tubercles present.

Alate viviparous female.—(Plate I, Fig. 5; Plate II, Figs. 11, 14 and 15). Described from type and 10 paratypes taken on *Polemonium* sp., in Cherokee Park, Colorado, September 20, 1915, by L. C. Bragg.

Color: Abdomen light green, slightly dusky on median portion; thorax and head black, with intersegmental membranes green; cauda pale greenish; antennæ and legs, except proximal one-third of femora

and tibiæ, dusky brown to blackish, black on tips of joints and tarsi; cornicles pale greenish to colorless; stigmas pale honey-yellow.

Measurements: Body, to base of cauda, 2.6 mm.; hind tibiæ, 2 mm.; antennæ, 3 mm.; joints as follows: III, .90 mm. (.76 to .93 mm.); IV, .47 mm. (.44 to .50 mm.); V, .47 mm. (.43 to .49 mm.); VI, .13 mm. + .82 mm. (.70 to .92 mm.); cornicles, .65 mm.; cauda, .22 mm.

Structural characters: Secondary sensoria on antennæ tuberculate; on joint III, 90, scattered throughout entire length of joint; on IV, 10 and 16 (10 to 20) mostly on proximal one-half of joint; none on V; hairs, cornicles, cauda, and tubercles as in apterous viviparæ; fore wings with mediæ twice branched; hind wings with two cross veins.

Male.—(Plate I, Fig. 6; Plate II, Fig. 12). Described from type and 2 paratypes taken on *Polemonium* sp., in Cherokee Park, Colorado, September 20, 1915; collected by L. C. Bragg.

Color: Head and thorax reddish-brown to black; abdomen reddish-brown with large areas of light honey-yellow surrounding bases of cornicles; cauda pale reddish-yellow; legs pale with tips of femora dusky and tips of tibiæ and entire tarsi black; antennæ dusky to black throughout; cornicles pale yellowish; stigmas dusky honey-yellow.

Measurements: Body, to base of cauda, 2 mm.; hind tibiæ, 1.70 mm.; antennæ, 3 mm.; joints as follows: III, .68 mm. (.68 to .73 mm.); IV, .44 mm. (.40 to .44 mm.); V, .48 mm. (.45 to .48 mm.); VI, .15 mm. + .95 mm. (.90 to 1.03 mm.); cornicles, .35 mm. (.30 to .35 mm.); cauda, .12 mm. (?).

Structural characters: Alate; secondary sensoria on antennæ, tuberculate, scattered throughout entire length of joints, on III, 71 (71 to 83) in number; IV, 30 (21 to 30); V, 16 (13 to 16); other characters as in alate viviparæ.

Collections were made on leaves and stems of *Polemonium foliosissimum* (?) in altitudes of about 7,000 feet on eastern slope of Rockies in northern Colorado, by L. C. Bragg and the junior author as follows:

Apterous summer viviparous female.—One collection, September 9.
Alate viviparous female.—Three collections, June 26 to September 4.
Male.—One collection, September 20.

Types in collection of the United States National Museum (Slides No. 41,920); paratypes in collection of the Colorado Agricultural Experiment Station.

This species was very abundant in the cases discovered. In all collections the alate form predominated, in fact, in the June collection a large number of alatæ were found, but not a single apterous example.

Myzus polemonii n.sp. bears some resemblance to *Macrosiphum purpurascens* Oest., but differs in the larger size of the body, 3 mm., the greater length of the spur, .70 to .90 mm., and the larger number of antennal sensoria on joint III, while *purpurascens* Oest. has body length, 2mm.; spur, .40 to .54 mm., and sensoria on joint III, 19 to 26 in number.

Amphorophora geranii, n. sp.

Apterous summer viviparous female.—(Plate I, Fig. 8; Plate II, Figs. 16, 18, 20 and 22). Described from type and numerous paratypes taken on *Geranium Richardsonii* in Big Thompson Canon, near Estes Park, Colorado, July 16, 1915, by L. C. Bragg; also numerous paratypes taken near Boulder, Colorado, June 30, 1912, and August 16, 1912, and one taken at Lyons, Colorado, June 11, 1916, all on above mentioned host and by L. C. Bragg.

Color: Dull green-yellow, pinkish in some paratypes, lighter anteriorly, on abdomen mottled with grass green tinged with dusky, especially on dorso-medial line to region of cornicles; cauda concolorous with body; legs pale greenish to pale brownish with tarsi and tips of tibiæ dusky to blackish; antennæ dusky except joints I and II and base of III; cornicles pale greenish on proximal one-third, dusky on distal two-thirds.

Measurements: Body, to base of cauda, 3.65 mm.; hind tibiæ, 2.80 mm.; antennæ, 3.90 mm.; joints as follows: III, .85 mm. (.71 to .93 mm.); IV, .78 mm. (.72 to .97 mm.); V, .62 mm. (.54 to .79 mm.); VI, .18 mm. + 1.02 mm. (.93 mm. to 1.20 mm.); cornicles, .95 mm. (.72 to 1.05 mm.); cauda, .43 mm.

Structural characters: Secondary sensoria on antennal joint III only, 5 and 8 (4 to 8) in number; hairs on body slightly capitate, .05 mm. long, rather sparse; on antennæ similar but rather numerous; on legs similar but more numerous; on cauda pointed, curved, .09 mm. long, and 6 or 7 on a side; cornicles slightly swollen on inner side of distal half, very slightly imbricated or smooth; frontal tubercles large and diverging; lateral tubercles lacking; ocular tubercles distinct.

Alate viviparous female.—(Plate I, Fig. 7; Plate II, Figs. 17, 19 and 21). Described from type and one paratype taken on *Geranium Richardsonii,* near Lyons, Colorado, June 11, 1916, another paratype taken at Boulder, Colorado, June 30, 1912, and one other taken near Estes Park, Colorado, July 16, 1915, on same host as above and by L. C. Bragg.

Color: Thoracic lobes brownish, remainder of dorsum dull green-yellow, tinged with grass green on pronotum and mottled with sooty green on abdomen, especially on median line to region of cornicles; cauda concolorous with body; cornicles pale on proximal one-third, dusky on distal two-thirds; antennæ dusky except joints I and II and base of III; legs pale brownish with tarsi and tips of tibiæ black; stigmas dusky honey-yellow.

Measurements: Body, to base of cauda, 3.15 mm.; hind tibia 2.90 mm.; antennæ, 4 mm.; joints as follows: III, .82 mm. (.71 to .92 mm.); IV, .85 mm. (.73 to .92 mm.); V, .72 mm. (.55 to .78 mm.); VI, .21 mm. + 1.10 mm. (1.05 to 1.35 mm.); cornicles, .85 mm. (.70 to .95 mm.); cauda, .35 mm.

Structural characters: Secondary sensoria on antennal joint III only, 17 (14 to 26) in number; hairs, cornicles and tubercles as in apterous summer viviparæ; fore wings with mediæ twice branched; hind wings with two cross veins.

Collections were taken on *Geranium Richardsonii* in foothills of eastern slope of the Rockies, mostly in northern Colorado, by L. C. Bragg and the authors, as follows:

Apterous summer viviparous female.—Twelve collections, June 7 to August 22.
Alate viviparous female.—Seven collections, June 7 to July 16.

Types in United States National Museum (Slides No. 41,922); paratypes in collection of Colorado Agricultural Experiment Station.

This species resembles *Amphorophora cicutae* Shinji on *Cicuta virosa* var. *californica*. It differs in proportions between antennal joints III and IV which are subequal in *A. geranii* while they are as 110 to 90 in *A. cicutæ*. The sensoria are apparently more numerous on antennæ in *A. geranii*, though some individuals did not show more. The difference of host also makes it more advisable to consider the two species distinct until more extensive study and biological tests can be carried out.

Rhopalosiphum bossekiæ, n. sp.

Apterous summer viviparous female.—(Plate I, Fig. 9; Plate II, Figs. 23, 24 and 25). Described from type and 7 paratypes taken on *Bossekia* (*Rubus*) *deliciosa* at Boulder, Colorado, July 1, 1912, by L. C. Bragg, also 14 paratypes taken June 11, 1909, and 1 taken June 30, 1915, on same host at Fort Collins, Colorado, by the senior author, also numerous others taken on same host, at Boulder, Colorado, August 11, 1912, and at Fort Collins, Colorado, June 13, 1918, by L. C. Bragg, and July 26, 1911, by the junior author.

Color: Light greenish-yellow, with green longitudinal streak on median line in region of cornicles; cauda and cornicles concolorous with body; antennæ somewhat dusky, except first three joints, which are pale yellowish; legs pale except tarsi and tips of tibiæ which are dusky to blackish; eyes dark red or black; red eyes of embryos are visible through dorsum of abdomen; surface of body rugose or reticulated.

Measurements: Body, to base of cauda, 1.80 mm. in length; hind tibiæ, 1.00 mm. (.60 to 1.10 mm.); antennæ, 1.30 mm. (.90 to 1.30 mm.); joints as follows: III, .34 mm. (.20 to .42 mm.); IV, .24 mm. (.13 to .31 mm.); V, .20 mm. (.14 to .26 mm.); VI, .10 mm. + .46 mm. (.30 to .55 mm.); cornicles, .47 mm. (.36 to .55 mm.); cauda, .11 mm.

Structural characters: Secondary sensoria present on antennal joint III, 2 (0 to 3) in number; hairs on body blunt or capitate, .03 to .04 mm. in length, and fairly numerous; on antennæ blunt, .01 mm. long and sparse; on legs similar to those on body; on cauda pointed, curved, .05 to .06 mm. long, and 3 or 4 on a side; cornicles somewhat swollen on inner side on distal one-third and slightly curved at base, neither reticulated nor imbricated, but somewhat transversely wrinkled or rugose on proximal one-third; cauda nearly parallel sided, rounded

at tip and without evident constriction; frontal tubercles not distinct; lateral tubercles inconspicuous, found on abdominal segments 2, 3 and 4; ocular tubercles present.

Alate viviparous female.—(Plate I, Fig. 10; Plate II, Fig. 26). Described from type taken on *Bossekia deliciosa*, at Boulder, Colorado, July 1, 1912, by L. C. Bragg, 5 paratypes taken on the same host, at Fort Collins, Colorado, June 11, 1909, and June 30, 1915, by the senior author, and 2 other paratypes taken June 13, 1918, by L. C. Bragg, on same host and locality.

Color: Abdomen and pronotum pale green mottled with darker on dorsum of abdomen; head and thorax yellowish-brown; antennæ slightly dusky except first two joints and base of third; cauda, cornicles and legs pale brownish-yellow, except tips of tibiæ and entire tarsi which are black or blackish.

Measurements: Body, to base of cauda, 1.80 mm.; hind tibiæ, 1.15 mm.; antennæ, 1.75 mm.; joints as follows: III, .43 mm. (.28 to .48 mm.); IV, .28 mm. (.25 to .33 mm.) V, .23 mm. (.20 to .32 mm.); VI, .11 mm. + .55 mm. (.55 to .65 mm.); cornicles, .45 mm. (.40 to .52 mm.); cauda, .19 mm.

Structural characters: Secondary sensoria on antennal joint III only, 10 (5 to 12) in number; hairs, cornicles, cauda, and tubercles as in apteræ; fore wings with mediæ twice branched; hind wings with two cross veins.

Collections were taken on *Bossekia deliciosa* in foothills of eastern slope of northern Colorado, by L. C. Bragg and the authors as follows:

Apterous summer viviparous female.—Seven collections, June 13 to August 30.
Alate viviparous female.—Two collections, June 30 and July 1.

Types in collection of the United States National Museum (Slides No. 41923); paratypes in collection of Colorado Agricultural Experiment Station.

This species resembles *Aphis rubicola* Oest. in the number of antennal sensoria and wrinkled appearance of the cornicles but measurements of both antennæ and cornicles differ greatly and the shape of the cornicles clearly shows the two to belong to different genera.

EXPLANATION OF PLATES.

PLATE I.

Macrosiphum williamsi, n. sp. 1, apterous summer viviparous ♀; 2, alate viviparous ♀.

Myzus leucocrini, n. sp. 3, apterous summer viviparous ♀; 4, alate viviparous ♀.

Myzus polemonii, n. sp. 5, alate viviparous ♀; 6, ♂.

Amphorophora geranii, n. sp. 7, alate viviparous ♀; 8, apterous summer viviparous ♀.

Rhopalosiphum bossekiæ, n. sp. 9, apterous summer viviparous ♀; 10, alate viviparous ♀.

PLATE II.

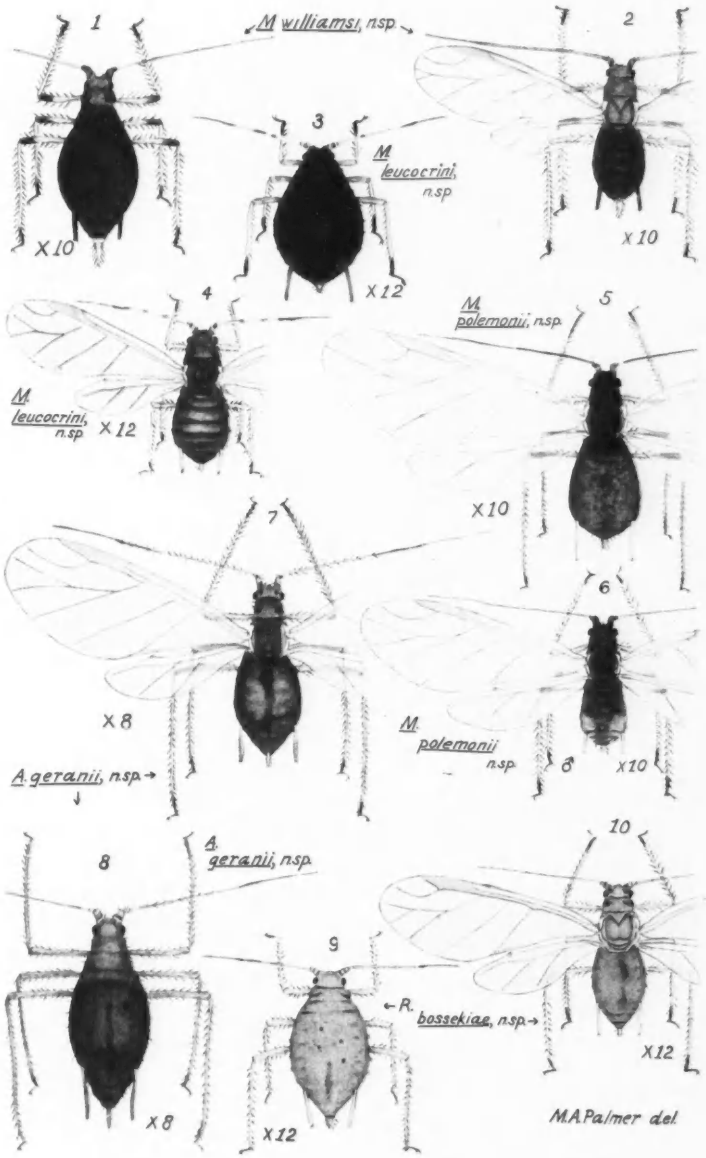
Macrosiphum williamsi, n. sp. 1, antenna of apterous summer viviparous ♀; 2, antenna of alate viviparous ♀; 3, cauda, and 4, cornicle of apterous summer viviparous ♀.

Myzus leucocrini, n. sp. 5, antenna, and 6, cornicle of apterous summer viviparous ♀; 7, antenna, 8, cornicle, and 9, cauda of alate viviparous ♀.

Myzus polemonii, n. sp. 10, antenna of apterous summer viviparous ♀; 11, antenna of alate viviparous ♀; 12, antenna of ♂; 13, cauda of apterous summer viviparous ♀; 14, cauda, and 15, cornicle of alate viviparous ♀.

Amphorophora geranii, n. sp. 16, antenna of apterous summer viviparous ♀; 17, antenna of alate viviparous ♀; 18, vertex of apterous summer viviparous ♀; 19, vertex of alate viviparous ♀; 20, cauda of apterous summer viviparous ♀; 21, cornicle of alate viviparous ♀; 22, cornicle of apterous summer viviparous ♀.

Rhopalosiphum bossekiæ, n. sp. 23, antenna, 24, cornicle, and 25, cauda of apterous summer viviparous ♀; 26, antenna of alate viviparous ♀.


1
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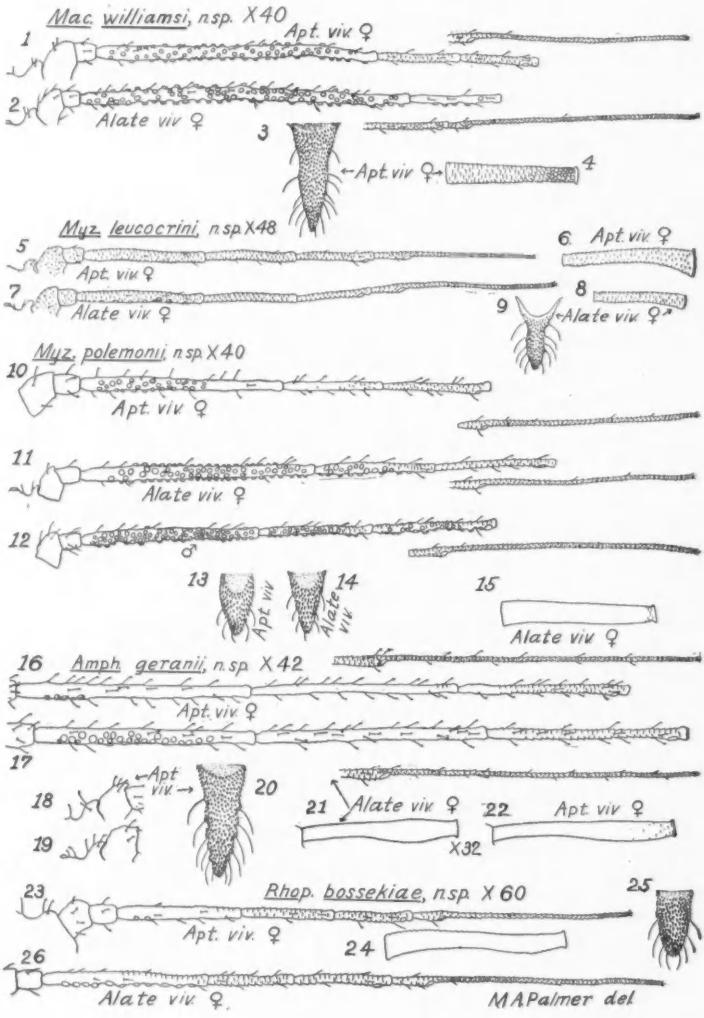

Gillette and Palmer

NOTES ON THE IMMATURE STAGES AND BIOLOGY OF A BIRCH CASE-BEARER.*

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During the summer of 1927 case-bearing larvæ were found causing serious injury to white and gray birches near Newport Mountain, in the town of Bar Harbor, Mount Desert Island, Maine. The infestation was not considered important, as it occurred on an area that had suffered recently from fire and on trees that were in a somewhat weakened condition. During the summer of 1928, however, the insect was found in other parts of Bar Harbor attacking healthy trees and causing almost complete destruction of the leaves of those trees so that it can be said to be an important pest of birch trees in the infested area. The insect does not appear to be widespread in its distribution for, with the exception of the relatively heavy infestation on Mount Desert Island, most of which is within the limits of the town of Bar Harbor, there are but two towns on the mainland (Trenton and Ellsworth) in which the insect has been found. The limited area of the infestation on the island and the spread of the insect along the main road of travel from the island to the mainland and on the mainland would lead one to assume that the insect concerned was either a relatively recent introduction from some foreign country or a species occurring in some other part of this country and but recently transported to Mount Desert Island. This was not found to be the case, however, for specimens of the adult which were sent to Mr. Carl Heinrich, of the United States National Museum, were determined by him as belonging to a new species (*Coleophora salmani* Heinrich) the description of which appeared in the Proceedings of the Entomological Society of Washington, Vol. 31: 18, 1929.

*The material presented in this paper is the result of investigations conducted for the Maine Forest Service under the direction of Mr. H. B. Peirson.

NOTES ON THE IMMATURE STAGES.

Egg.—Length 0.35 to 0.44 mm.; width 0.24 to 0.28. The egg is usually oval although its shape may be modified somewhat by the presence of other eggs touching it or by the hairs of the leaf to which it is attached. The surface of the egg is finely pitted, the micropylar portion having a number of rounded projections which give it a "pebbled" appearance. It is yellow or orange in color when first laid, but, as the embryo develops, becomes light yellow and a dark area appears at the micropylar end due to the color of the head capsule of the developing larva which shows through the shell.

Larva.—Four distinct instars have been observed, but calculations made according to Dyar's Law (Psyche 5: 420–422, 1890) from measurements of the head capsules indicate that there are five larval instars, the first, second, third and fifth of which have been observed and collected. The shape of the larva is eruciform. The thoracic segments are somewhat wider than the other body segments and the dorsum of the terminal abdominal segment, in the later instars at least, is scleritized heavily, possibly to act as a protection against injury for the distal portion of the case borne by the larva is open. The thoracic legs are well developed. The anal prolegs are the only ones which are distinct and each of these bears a single transverse row of crochets. The later larval stages show a slight development of prolegs on the 3rd, 4th and 5th abdominal segments and each of the prolegs bears a variable number of crochets.

1st Instar.—Length 1.17 mm.; width of head capsule 0.14 mm. Head capsule, thoracic legs and dorsum of the 1st thoracic segment scleritized. Body cream-colored or greenish.

2nd Instar.—Average length 1.55 mm.; width of head capsule 0.19 mm. Head capsule, thoracic legs and dorsum of 1st and 2nd thoracic segments and of anal segment of abdomen scleritized. Body greenish in color.

3rd Instar.—Width of head capsule 0.27 mm. Body very similar in appearance to larvæ of the 2nd instar except that it is darker in color, and, during the period of hibernation, is contracted.

4th Instar.—Larvæ of this stage have not been observed, but calculations show there to be one instar having a head width of approximately 0.34 mm.

5th Instar.—Width of head capsule 0.49 mm. (Calculated as approximately 0.46 mm.*). Body shape and color similar to 2nd instar but somewhat larger and darker.

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*The specimens from which the measurements were made had been pressed and dried in their cases. Although the specimens showed but very slight distortion of the head capsule, it is possible that the difference between the observed and the calculated widths is due to the flattening of the head capsule in the process of pressing the cases.

LARVAL CASES.

The larvæ of the 1st instar do not form cases, but mine in the leaves. There have been four different types of cases found and the larvæ of the 2nd to 5th instars (inc.), as well as the pupal stage occur in one or another of these types. These types of cases are similar in shape to those of the Cigar Case-bearer (*Coleophora fletcherella* Fernald).

Type 1.—This type of case is formed entirely of the epidermal layers of the mined area of the leaf. It is of variable size, but on the average is about 2.5 mm. long from tip to tip. It consists of a curved tubular portion, open at both ends, one of which is attached to the leaf, the other serving as an opening through which the larval excreta is voided. There are two fin-like longitudinal ridges formed by the cut edges of the epidermal layers, one dorsal and one ventral. The dorsal one, which is on the convex side of the tubular portion, is narrow and soon wears (?) away. The ventral "fin" is more persistent, remaining on the case and forming a lamina which fills the space on the concave or ventral side formed by the curving of the tubular portion. Larvæ of the 2nd instar only have been found inhabiting this type of case.

Type 2.—This type of case is of about the same size as the preceding and is made of the same material. It differs in that the distal portion of the central tube is flattened and nearly closed and that the fin-like margins of the ventral and dorsal sides of the case are continued over the distal portion of the case. This case may be formed from a case of type 1, but the flattening of the distal end and the presence of the ridge extending over this portion would indicate that this is the second case to be formed by a larva. Larvæ of the 3rd instar inhabit this type of case.

Type 3.—This case differs from the preceding in shape and in the material used for its construction. It is somewhat larger, being from 3 to 3.5 mm. from tip to tip and the curve of the tubular portion in which the larva remains is much more abrupt than in the preceding types. The distal portion only is composed of the epidermal layers of a leaf. The basal portion, usually nearly half the entire case, is composed of a granular material of indeterminate origin which has been placed in layers around the mouth of the portion formed from the epidermal layers. The granular material forming the layers is held together by silken threads. The distal portion of the case is somewhat flattened, although not as much as in a type 2 case. Only one larva has been found in a case that was distinctly of this type, but it is known that the 3rd and 4th larval instars occur at the time when these cases are to be found. This type is evidently a type 2 case to which the granular material has been added at the base. Several cases containing hibernating larvæ of the 3rd instar have been found that had a small amount of granular material at the base, but the extreme development of this type of case does not usually occur until late spring or early summer.

Type 4.—An elongate, cigar-shaped case which is usually over 5 mm. in length and which has a width of from 1.5 to 2 mm. at its widest portion. It is formed entirely of epidermal layers of a leaf. When first formed it has relatively wide dorsal and ventral "fins" running the full length of the case, but these disappear after a few days and the case becomes nearly cylindrical. The basal opening is cut at an angle of about 45° so that, when it is attached to a leaf the case is not vertical to the leaf surface but slopes at about this angle. The apex of the case is open, but its edges are pinched together so that the larva contained therein is partially protected. Larvæ of the last or 5th instar and pupæ are to be found in cases of this type.

Pupa.—Length 3.3 mm. to 4.7 mm.; width 1 mm. It varies in color from a light to a dark brown, according to the age of the pupa. The tip of the abdomen is blunt and rounded and a protuberance bearing two short, conical spines at its apex projects from each side of the abdomen near the tip. The pupa is formed in a type 4 case.

BIOLOGY.

General.—There is but one generation a year of this insect in the locality in which these studies were made. The eggs are laid about the middle of July and hatch during the first week of August. The larvæ feed for a time between the epidermal layers of the leaf and form their cases from the layers of the area mined. They hibernate in their cases on the twigs of the host plant and begin their feeding activities again in the spring, becoming full grown about the last of June or first of July and pupating at that time.

Adult habits.—The adults are not very active in intense sunlight and usually remain hidden on the undersides of leaves, on stems, or in any partially shaded place affording shelter during the daytime. They rise up in numbers when the foliage is disturbed but soon alight and hide again. On cold or rainy days they also remain in protected places. They rest on the leaf surface with the anterior portion of the body raised from the leaf and with the tip of the abdomen touching the leaf surface. The grayish antennæ are held together straight out in front of the body and the wings are folded so that the outline of the insect is triangular, the antennæ projecting from the head or apex of the triangle as a single thread-like process. The habit of hiding, which is noticeable in the adult, would seem to indicate that the insect is negatively phototropic during this stage. Adults liberated in the laboratory, however, always flew to a window, but those which emerged in boxes into one

side of which a bottle had been inserted were not attracted to the light entering through the bottle and remained motionless inside the box.

The first adults to be reared in the laboratory in 1927 emerged from field collected material on July 14, but, as eggs were found in the field at that time, emergence under natural conditions must start somewhat earlier. In 1928 the first adult was found in the field on July 6 although the greater number of adults did not emerge from the field collected material held in the laboratory until after July 10. Few adults were to be found in the field after the first week of August.

The individuals mate a few hours after emergence and a pair has been noted as remaining in the copulatory position from 9:30 a. m. until 4:30 p. m., a period of seven hours. Other pairs noted separated after a shorter period. When mating, the two individuals remain nearly motionless, the tips of their abdomens joined and the insects facing in opposite directions. In one lantern globe cage which was attached to a twig of a white birch tree in the field an example of the attraction of males by females was observed. The cage contained three living females and two males, one of which was mating with a female at the time of observation. Outside the cage, however, six males were found to have crawled up under the cheese cloth covering of the top of the lantern globe in an attempt to gain access to the females. Four of these males were living and were endeavoring to pass the restricting rubber band which held the cheese cloth in position while two had died in attempting to gain access to the interior of the cage.

In the glass cages on trees in the field two females laid 9 eggs each, one 10 eggs and one 21 eggs in one day of twenty-four hours. In the laboratory one female is recorded as laying 20 eggs on the first day, 8 between 8:30 a. m. and 5:00 p. m. of the second day, 2 between 5:00 p. m. and 8:30 a. m. of the following morning, 3 the third day, 2 the fourth day and 4 in the three days following or a total of 39 eggs laid over a period of seven days. Other records of females which were reared and mated in the laboratory show that the greater number of eggs are laid during the first day after mating and that seven days is about the average length of time during which eggs are laid. The length of life of adult females has been recorded as being from 7 to 10 days., from emergence from the pupa to death. Males usually live from 6 to 8 days.

Egg.—Eggs are found in the field only on the under surfaces of leaves although a few eggs were laid on buds or on the upper surfaces of leaves under the unnatural conditions imposed on the female by the lantern globe cages. Eggs have been found deposited under field conditions on *Betula alba*, *Corylus americana* and *Alnus sp.* and, although the white birch seems to be the favorite host, many eggs are laid on the other two host plants. Gray birch is subject to extensive injury by the larvæ of the case-bearer, but, in spite of careful search, no eggs have been found laid on the leaves of this species. This may be due to the lack of heavy pubescence on the under surface of the gray birch leaf for the plants on which eggs have been found all have the under surface of the leaf densely pubescent and the eggs are usually found among and attached to the hairs of the leaf. The eggs are usually laid among the hairs at the junctions of the midrib with the main lateral veins. They may be laid beside the midrib and some have been found beside the lateral veins. Few eggs have been found on the lower leaf surface away from the protection afforded by the larger veins. They may be laid singly or in groups and when laid in groups, no definite order of placement is observed.

As many as 33 eggs have been found in the field on the under surface of a single leaf. All the leaves of several branches of trees occurring in the heavily infested locality in which this insect was first found were examined and it was found that there was an average of 6.2 eggs per leaf. Similar counts were made of the leaves on branches which were shaded, branches exposed to the sunlight and branches in partial shade. There was an average of 10.5 eggs per leaf on shaded branches, 3.5 eggs per leaf on branches exposed to sunlight and 4.6 eggs per leaf on branches in partial shade. This indicates that the amount of exposure of the leaves of a tree to sunlight may have some effect on the number of eggs laid on them.

I have but a few records of the length of the egg stage and these are accurate only to within two or three days. Those which have been taken, however, indicate an egg stage of about three weeks. Eggs have been recorded as occurring in the field from the second week in July until the first week in August.

Larval Habits.—The eggs of the birch case-bearer hatch about the first week in August. The larvæ emerging from these

eggs bite their way through the distal "pebbled" portion of the shell and wander over the lower surface of the leaf for a short time. They soon select a place, bite their way through the epidermis and begin to mine through the inner tissues of the leaf. One larva which was observed entering the leaf did not eat any of the epidermal tissue, but placed the particles beside the opening of the mine. When inside the leaf it fed normally on the tissues. It cannot, however, be definitely stated that the habit of rejecting the epidermal tissues is typical. It takes about two hours for a larva to completely bury its body in the leaf tissues.

Larvæ have been observed in their mines in the leaf as late as August 26. All but a very few of the larvæ collected from mines were of the 1st instar, but it is possible that they molt once in the mine and then cut their cases from the epidermal layers. This is suggested by the fact that a few larvæ of the 2nd instar have been taken from mines.

Cases of type 1 have been found in small numbers as early as August 24th, the number of cases of this type being found in the field increasing rapidly after that date. Cases of type 1 have not been found to contain larvæ of any but the 2nd instar. This instar is evidently completed by the second or third week in September for collections made by Mr. H. B. Peirson on September 16 revealed but two type 1 cases.

Type 2 cases are abundant during the latter part of September and in October and all the cases examined have been found to contain larvæ of the 3rd instar. It is in the 3rd instar and in a type 2 case that the case-bearer hibernates. From the time of the cutting of the first cases from the leaves until the migration which preceeds hibernation the larvæ of the 2nd and 3rd instars have been feeding in the usual manner of Coleophorids. The larva moves its case from one part of the leaf to another and fastens it down with silken threads, mines through the leaf by crawling part way out of the case and, when it has eaten all the tissue it can in this manner, unfastens the case, crawls with it to another part of the leaf and repeats the process. When ready to hibernate it migrates to a twig and attaches the case. The host plants attacked by these late summer and fall instars are the same as those on which the eggs were laid.

Feeding is resumed in the spring and the mines made by the feeding larvæ at this time are much larger than those made in the fall. Larvæ of the 4th instar have not been collected or measured, but the type 3 cases occur during the spring and early summer and the 4th instar larvæ must occur at this time so that it is permissible to speculate that the larvæ of this instar do much of the feeding done at this time of year. It is not known when the majority of the larvæ molt and enter the final or 5th instar. Cigar-shaped cases containing full grown and feeding larvæ have been recorded in the field as early as July 2 and one individual has been noted as having left its type 3 case on July 9 and as forming its type 4 case on July 10. Usually, however, most of the larvæ have formed their cigar-shaped casse before this time and have already pupated.

In addition to the host plants attacked by the early fall instars there are three others upon which the larvæ of the later instars have been found feeding to some extent, although, to my mind, the occurrence and feeding on two of these plants was purely accidental. The plants concerned are *Salix sp.*, *Quercus rubra*, and *Betula populifolia*, the last-named evidently being a preferred host, although as noted above no eggs have been found on plants of this species.

Pupa.—The case-bearer usually migrates to nearby twigs when ready to pupate, although many pupate on the leaves. It is probable that, during the migration, many drop from the trees on which they have been feeding to the plants beneath for trunks, leaves and needles of a great number of species of plants found beneath the infested trees had many pupal cases on them although no feeding injury was observed. The larva, on reaching the place at which it is to pupate, firmly fixes the base of the case to the object, sometimes merely by attaching it with silken threads, at other times, as was observed on white pine needles, by excavating a hole in the needle and firmly attaching the edge of the case to the rim of the excavation. Then it spins a silken plug to close the hole at the base of the case and turns around so that its head is facing towards the distal end. It molts again and enters the pupal period, the molted skin being pushed down on the silken plug. Full grown larvæ enter the pupal stage over a period of several weeks and the majority of larvæ have pupated by the first week in July. Although early adults appear before some late larvæ

have pupated the greater number of individuals do not emerge until the second week in July. The pupal stage has been recorded as lasting 14 or 15 days.

Natural control.—This species does not seem to be attacked by many predators or parasites although a few have been collected or reared. The mortality of hibernating larvæ must be very high, however, for many dead larvæ have been found in their cases on the twigs and leaves.

Trombidium sp.—Nymphal stages of a mite, the identity of which was kindly determined by Dr. Nathan Banks, were found on the leaves of birch feeding on eggs of the case-bearer. The mites suck the contents from the eggs and were particularly abundant in the glass cages on the trees. In one cage 62 out of 66 eggs had been sucked and in another 29 out of 57 eggs had been destroyed. One mite was observed eating a dead case-bearer moth. Outside the cages the eggs of the case-bearer were attacked to some extent, but the activities of the mites were not very noticeable.

Several individuals of Ichneumonoid Hymenoptera were reared from the pupæ of the case-bearer. Dr. C. F. W. Muesebeck kindly determined them as of the following species: *Hemiteles tenellus* (Say), *Itoplectis conquisitor* (Say) and *Orgilus sp.* and stated that the first and second-named "are very common species, the former usually, and the latter very frequently acting as hyperparasites." The exact relations of these with the case-bearer were not determined and it is very probable that they may constitute a portion of a hyperparasitic group of species. The status of *Orgilus sp.* was not determined.

A HANDBOOK OF THE DRAGONFLIES OF NORTH AMERICA. By J. G. Needham and Hortense Butler Heywood. Charles C. Thomas, Publisher, Springfield, Ill. and Baltimore, Md. pp. I–VIII–378.

Primarily intended for collectors and students of systematic entomology this book includes much information relating to the habits and life-histories of this interesting group of insects. The first forty-six pages are devoted to a general discussion of the group, the structures used in classification and the general habits with directions for collecting and preserving. The remainder includes keys and descriptions for the identification of the North American species.

H. O.

NEW SYRPHIDÆ AND TACHINIDÆ.

C. H. CURRAN.
American Museum of Natural History.

Descriptions of new species of flies from various parts of the world are given herewith. Rather than present separate papers each dealing with a different faunal region, the descriptions are presented in the one paper. Disposition of the types is indicated following each species.

SYRPHIDÆ.

The species described below was collected by Dr. E. Escomel in the arid region of Peru and was forwarded, along with some other Diptera from the same source, by Dr. T. D. A. Cockerell, to whom I am greatly indebted for the privilege of retaining the specimens.

Volucella escomeli, new species.

In my key, (Ann. Ent. Soc. Amer., xix, p. 51, 1926) traces to couplet 30 where it fits neither alternative since the scutellum bears six or seven pairs of strong setigerous tubercles and the abdomen is mostly pale luteous yellow. If carried to couplet 32 it agrees fairly well with *concinna* Philippi but there is a slight facial tubercle and the frontal triangle is not nearly as wide transversely and is more acute above. Length, 12 to 16 mm.

Male.—Head sub-transluscent yellowish, the very small vertical triangle reddish. Face perpendicular, broad, widening below, slightly produced at the upper two-fifths, thence perpendicular to the lowest fourth where it recedes, the lowest part again perpendicular, the oral angles acute; oral margin evenly oblique in profile, the cone sharp. Pile black on the front, the sides and middle of the face and on the vertical triangle, elsewhere fine and pale yellowish, on the eyes grayish white; no long occipital pile. Antennæ reddish; third segment regular, slightly tapering; arista mostly brown, with long black rays above and below; the antennæ not one-third as long as the face.

Thorax greenish black, the broad sides of the mesonotum and most of the mesopleura luteous; pile abundant, very fine, crinkly, grayish white, the mesonotum and upper part of the pleura with coarser black hairs intermixed. Scutellum large, transluscent luteous, with short black hair on the disc, the border with fine, pale pile; the apical tubercles are strong, the basal pair obsolete or nearly so; a deep concavity between the apical pair of tubercles. Four to six strong prescutellar bristles.

Femora and tarsi black, the apices of the former and the basal two or three segments of the posterior tarsi except their apices, reddish, the tibiæ reddish yellow. Hair black.

Wings hyaline; stigma small, blackish; small crossvein narrowly blackish; marginal cell slightly widened, the petiole long, apical.

Abdomen transluscent luteous, the first three segments with a narrow black vitta which is interrupted at the second incisure and continues as an oval spot onto the fourth segment, the sides of the third and fourth segments with large blackish triangles posteriorly, the second with very small ones, those on the third extending obscurely along the posterior border, the fourth segment with brownish stain except on the broad base and apex. Pile very short, coarse, black, the broad bases of the apical three segments clothed with fine whitish pile. Venter pale yellow; third sternite with a small transverse black spot apically, the fourth black on the median half, the pile black only on the black part of this sternite.

Female.—Front moderately wide, the làteral depressions large, sharply defined, wider than the gentle median convexity; front widening anteriorly, wholly black haired. Antennæ slightly larger than in male. Fifth abdominal segment small, brown with the middle broadly yellow.

Type male and allotype female, Arequipa, Peru, (Dr. E. Escomel) in Curran collection. Paratypes: 2♂ 5♀, Yura, Peru, (T. D. A. Cockerell), in American Museum of Natural History.

Volucella concinna Philippi, with which this species is likely to be confused, has black triangles on all the sternites.

Baccha bromleyi n. sp.

Blackish, the wings lightly brownish, hyaline basally; sides of abdomen parallel. Length, 11 mm.

Male.—Face, front and cheeks, reddish yellow, the cheeks somewhat brown in front. Occiput black, thickly grey pollinose, whitish pilose below, yellowish above: vertical triangle black, thinly brown pollinose, black pilose, the pile of the front and face black. Front as long as the face, very gently convex, more prominent anteriorly, where there is an oval, shining black central spot, the sides narrowly whitish pollinose; eyes touching for a distance about equal to the length of the vertical triangle. Face receding, with a large, moderately prominent tubercle, the sides of the face whitish pollinose. Antennæ dark reddish, the third segment brown on apical half, decidedly wider than long, the apex obtusely rounded; arista brown except basally.

Mesonotum and scutellum aeneous, pale pilose, the broad lateral margin in front of the suture, the posterior calli and the base of the scutellum rather obscurely yellow; scutellum black haired. Pleura blue-black, the posterior half of the mesopleura and a rectangular, contiguous spot on the sternopleura, yellow. Pile yellowish.

Legs reddish yellow, the posterior femora with a very broad, preapical brown band, their tibiæ reddish brown on the apical two-thirds; posterior tarsi brownish above. Pile black except basally on the femora.

Squamæ whitish yellow, with yellow border and fringe; halteres yellow. Third wing-vein straight. Allula large.

First abdominal segment aeneous, the sides broadly yellow; abdomen bronze-black, sub-opaque except apically; second segment at the middle with a large, inwardly rounded reddish spot on either side, the spots reaching the lateral margin in their full width; third segment with similarly colored spots which are more elongate, more oblique and slightly concave in front and situated wholly before the middle of the segment; fourth segment with spots as on the third but they are longer than wide, more oblique and concave in front and reach forward to the basal sixth of the segment. Pile black and rather abundant, partly yellow on the sides of the first segment.

Holotype, male, Santiago, Las Vegas, Cuba, April 10, 1926, (S. W. Bromley), in Curran Collection.

Baccha carlota n. sp.

A large species, mostly blackish, with yellow vittate thorax, the costal border reddish and brown. Length, 14 mm.

Female.—Face and cheeks pale yellow, the former with a broad, median ferruginous vitta which does not quite reach the antennal base; front ferruginous, the upper fourth dull black, the sides broadly yellow, a yellow spot above each antenna. Hair of occiput and lower half of face, yellow, elsewhere black. Antennæ rusty reddish. Face slightly receding below, the tubercle large, rounded.

Mesonotum ferruginous, with a pair of broad, widely separated reddish yellow or orange vittæ which curve slightly outwards and taper posteriorly from a little behind the suture, on the sub-posterior fifth with a narrow, median vitta of similar color; a broad yellow lateral vitta, broadly interrupted between the suture and the base of the wings. Pleura with a broad yellow fascia extending from the upper margin immediately before the base of the wings to the middle of the sternopleura, the prothorax wholly and a large spot on the hypopleura, yellow. Pile of dorsum, brown, of the sides and anterior border, yellow. Disc of scutellum brown, the border yellow, hair wholly black.

Legs yellow or reddish yellow, the hair yellow; posterior four coxæ brownish, posterior femora black except the apical sixth, the posterior tibiæ ferruginous on the apical three fifths; the black portions of the hind legs bear longer, abundant black hair and the upper surface of the posterior basi-tarsus is black haired.

Wings reddish luteous in front of the third vein, becoming brown apically; third vein rather strongly curved forwards from a little beyond the middle of the apical cell; apical crossvein bisinuate; discal crossvein oblique except on the posterior sixth. Squamæ whitish, the border and moderately long fringe, yellowish; halteres yellow.

First abdominal segment yellow, with the broad posterior border ferruginous, the pile long and whitish. Second segment reddish ferruginous, the basal fifth, broadly interrupted in the middle, yellow; third and following segments ferruginous, the basal third of the third segment yellow, the sides of the abdomen with a more reddish tinge. The abdomen is strongly spatulate, narrowest at the basal fourth of the second segment, gradually widening to the apex of the third, the fourth fully as wide as the thorax. Hair black.

Holotype, female, Mina Carlota, Trinidad Mountain, Cuba, March 24, 1925 (G. Salt), in Curran Collection.

Key to the Philippine Species of Baccha.

1. Wings not mostly brown..... 2.
   Wings almost wholly blackish brown.....*purpuricolla* Walker.
2. Scutellum unicolorous or nearly so, at least not black with a yellow apical border..... 3.
   Scutellum black with a yellow apical border.....*cochleariformis* Sack.
3. Abdomen with yellow spots or bands or only the fourth segment black.... 4.
   Abdomen yellowish on the basal half, the apical half black....*loriae* Meijere.
4. Scutellum partly or wholly black or brownish..... 5.
   Scutellum entirely yellow; fourth abdominal segment wholly black, *macgregori* n. sp.
5. Scutellum wholly black or with a black or brown discal spot..... 6.
   Scutellum yellow on basal half, black on apical half.....*signata* Sack.
6. Scutellum wholly black..... 7.
   Scutellum brown on the disc, with an entire yellow border..... 8.
7. Abdomen with yellow bands.....*austeni* Meijere.
   Abdomen with paired yellow spots.....*pulchrifrons* Austen.
8. Third antennal segment scarcely longer than wide; third longitudinal vein gently arched on its pre-apical section.....*meijerei* Kertesz.
   Third antennal segment one and one-half times as long as wide; third vein practically straight.....*amphithoe* Walker.

Baccha macgregori, new species.

Head yellow; thorax black; scutellum wholly yellow; abdomen reddish or reddish yellow, the fourth segment wholly black, the other segments with pale brownish suffusions. Length, 11.5 to 12 mm.

Male.—Frontal triangle, face and cheeks, yellow, without pollen and with very short, pale yellowish pile; occiput black, grey pollinose, pale yellow pilose. Vertical triangle shining black, very long and narrow, the ocelli situated at its anterior extremity, the row of hair yellow. Antennæ pale orange, the third segment slightly longer than wide; arista brown.

Thorax black; pleura thinly cinereous pollinose; pile yellow, on the dorsum appressed and rather golden, broad sides of the mesonotum in front, a spot above the anterior coxæ, a large spot on the sternopleura above, most of the mesopleura, upper half of the hypopleura and the scutellum, sulphur-yellow. Scutellum without ventral fringe, the sparse hair yellow. Humeri wholly bare.

Legs yellow, the posterior basitarsi brown; posterior femora and tibiæ sometimes extensively pale brownish. Hair very short, yellowish, black on the posterior femora.

Wings cinereous hyaline; subcostal cell pale brown; stigma dark brown, a rather narrow brown band extends along the costa from the stigma to the apex of the third vein. Apical crossvein very strongly curved outwards at the basal fourth, the discal crossvein less strongly so. Alula wanting. Squamæ and halteres yellowish, the squamæ without trace of fringe.

Abdomen reddish yellow; fourth segment wholly, basal half of the fifth and the extreme apex of the third, black, the second and third segments usually with a broad, somewhat darker band on the basal half, but its position variable. Genitalia yellowish. Pile sparse, short, black, yellow and longer on the first segment, sides of the second and on the genitalia.

Female.—Front very narrow, yellow in front of the ocelli; yellow haired; genitalia yellowish.

The abdomen of this species is long and slender, widening from the middle of the third segment, the second segment about as long as all the following segments combined.

Described from 2 ♂ 4 ♀, Manila, Philippines, (R. C. McGregor). Type and allotype in the United States National Museum.

Salpingogaster punctifrons, new species.

Allied to *pygophora* Schiner but the fourth sternite is thickly beset with black spinules and the apical projections of this sternite are more widely separated, more tapering and stouter; the spot above the antennæ is smaller, the face more retreating; the frontal triangle not with a low distinct convexity above, but almost evenly produced to the apex of the antennal prominence. Length, 15 mm.

Male.—Face reddish yellow, the middle line broadly ferruginous tinged, strongly retreating, the large rounded tubercle mostly below the middle of the face, decidedly less prominent than the antennal base. Frontal triangle ferruginous, its margin reddish yellow; a small, longitudinal ferruginous brown spot above the antennæ; frontal triangle oblique, scarcely concave on upper third, its apex convex. Vertical triangle as long as the contiguous portion of the eyes, narrow, over three times as long as broad, the ocelli situated on its front half, the anterior one remote. Occiput and vertical triangle blackish, the former, except along the orbits above, greyish pollinose. Pile of head fine, whitish, the ciliæ on the whole occipital orbits with a yellowish tinge. Antennæ yellowish red, the third joint dull, scarcely longer than the second, broadly rounded, first two joints rather abundantly black pilose; arista reddish, yellow basally.

Mesonotum black, its sides before the suture and the postallar calli, salmon yellow, behind the suture translucent brownish reddish,

on the dorsum with three rather broad brownish yellow pollinose vittæ. The extremely short, appressed pile is yellowish. A broad stripe on the pleura before the wings yellowish, a similarly colored area below the humeri; the pleura elsewhere ferruginous and without pile. Scutellum yellowish at base and apex, its disc brownish ferruginous.

Legs yellowish red, the bases of the tibiæ yellow, all the femora with some tiny bristles beneath. Wings yellowish hyaline, broadly darker, more yellowish brown, along the costa.

Abdomen rather ferruginous, the second segment and base of the third more reddish-ferruginous, the first segment yellow, brown apically, the mammiform projections acute apically. Pile yellow on first three segments black on apical segments. The apex of the abdomen is oval, the expansion commencing from the base of the third segment, the second segment longer than the two following combined, cylindrical, of equal width, slender.

Holotype, ♂, Cuba (Baker) in Leland Stanford University Collection.

Psilota fasciata n. sp.

Shining black, the abdomen with three reddish yellow fasciæ; legs partly reddish yellow. Length, 7 mm.

Male.—Head with rather thin silvery pollen, a vitta on the upper half of the face, most of the frontal triangle and the ocellar region bare; pile white, black on the vertical triangle, upper fourth of occiput and eyes, the lower fifth of the eyes with yellowish pile. Antennæ reddish yellow, the upper half of the third segment and the arista, blackish.

Thorax aneous on anterior half; pile yellow, a very broad band of black pile on the mesonotum between the wings, sometimes occupying the whole space between the suture and scutellum, the latter with yellow pile and with strongly impressed margin.

Tips of anterior four femora, their tibiæ and the first two segments of their tarsi, yellow, the basal two segments of the posterior tarsi yellow with the upper surface brown. Pile of legs yellowish, black on apical fourth of the femora and apical three tarsal segments.

Wings hyaline, the veins at the base and the stigma yellowish. Squamæ yellowish, the rim brownish except outwardly; fringe yellow. Halteres pale yellow.

Abdomen shining black; second segment yellowish on anterior two-thirds, the sides rather narrowly black, the yellow sometimes reaching narrowly to the lateral margins in front, and with a somewhat darker median vitta. Yellow band of third segment broadly interrupted in the middle, two-thirds as wide as length of segment; band on fourth segment reduced to a transverse, triangular yellow spot in either side at the base; the pale bands are well separated from the lateral margins. Pile yellow; black on the dorsum between the middle of the second segment and middle of the fourth. Second and third sternites and base of fourth, yellow.

Type male, and male *paratype*, Manila, Philippines (R. C. McGregor). Type in U. S. N. M.

Lepidostola colombia n. sp.

Black; antennæ brown, the first segment yellow; basal two segments of anterior tarsi and three segments of the posterior four, pale yellow; basal fourth of posterior femora reddish yellow. Length, about 6.5 mm.

Female.—Head shining black; the sides of the face broadly, an orbital spot opposite the base of the antennæ and another above the lower third of the front, sericeous; occiput, except the very broad upper border, yellowish grey pollinose; pile of occiput white, of vertex yellow, with a few black hairs above. Front strongly narrowed above, the vertex strongly produced upwards. Facial tubercle strong.

Thorax shining black, with a broad, median, thinly pollinose greyish vitta; the pleura, notopleura, anterior border of mesonotum and the posterior fourth, with scattered whitish squamulæ, the border behind the wings densely golden yellow squamose. Scutellum triangular, rounded apically, above with short, appressed black hair, the margin (below the tip) with some yellow hair. Mesonotum with inconspicuous, appressed black hair.

Legs with steel blue reflections; black haired, the femora with spines on basal half of lower edges; base of posterior femora and the pale tarsal segments, yellow haired.

Wings almost hyaline, yellowish in front, darker apically, the stigma yellowish. Squamæ white, with brownish border and fringe; halteres yellow.

First abdominal segment and narrow apex of the second, grey pollinose; second and third segments opaque black, with a very broad median vitta and the lateral margins, polished, the third with the apex moderately broadly shining and with a few squamulæ in the middle. Fourth segment shining black, with scattered whitish squamulæ. The pile of the basal two segments is yellow, on the apex of the second and on the following segments, black.

Holotype, female, Rio Frio, Magdalena, Columbia, July 13, 1927, (G. Salt), in Curran Collection.

The following key will aid in the recognition of the described species.

*Key to the Species of Lepidostola.**

1. Femora wholly black; abdomen not golden apically..... *colopus* Loew.
   At least the basal fifth of the posterior femora reddish; if this color not sharply defined the apical two abdominal segments are golden..... 2.
2. Crossvein closing discal cell margined with brown..... *similis* Will.
   Crossvein closing discal cell not margined with brown..... 3.
3. Wings with a narrow, incomplete, preapical brown fascia..... *pulchra* Will.
   Wings at most weakly clouded with brown..... 4.
4. Apical two abdominal segments golden..... *abdominalis* Will.
   Apical abdominal segments not golden..... 5.
5. Bases of anterior four femora yellow..... *perpolita* Johnson
   Anterior four femora wholly black..... *colombia* Curran

*L. *ortalina* Wulp, from Argentina, is omitted.

Cheilosia versicolor n. sp.

Similar to *illustrata* Harr. but the face bears black hair, the pile of the legs is differently colored, etc. Length, 12 to 14 mm.

Male.—Head black, greyish pollinose, the frontal and vertical triangles and the tubercle, thinly so; hair cinereous yellow, becoming more reddish on upper part of head; inner edges of facial side pieces, facial slopes, frontal triangle and vertical triangle except behind, black haired. Antennæ black; third segment small, semicircular, flattened above; arista black, short pubescent.

Thorax aeneous, the mesonotum behind the suture and the scutellum shining black, the pleura less shining below the wings, cinereous pollinose on anterior half. Pile pale yellowish to reddish yellow, black on the shining black portion, the posterior calli mostly and the free border of the scutellum broadly yellow pilose, the hair long. Scutellum without bristles.

Legs black; coxæ and anterior four legs black haired, the anterior coxæ with some pale hair basally on outer side; anterior four femora with short, tawny pile in front and long pale pile basally, their tibiæ with tawny pubescence anteriorly; posterior legs with reddish yellow pile, that on the tibiæ short and tawny, their tarsi black haired above.

Wings cinereous hyaline, sometimes with luteous tinge, a brownish cloud at the middle on the anterior half. Squamæ brown, with yellowish fringe; halteres with brown knob.

Basal half of second, whole of first and broad sides of the second segment, pale yellowish pilose, the abdomen elsewhere with long, tawny pile except on the broad sides of the third and narrow sides of basal half of the fourth segment, where the pile is thick and black. Venter pale haired on basal two segments, black haired beyond. The abdomen is aeneous, the basal segments somewhat hoary.

Female.—Front moderately wide, with a broad band of brownish grey pollen across the lowest fourth, the pile yellowish except across the ocelli, condensed laterally, the median third very thinly pilose above the pollinose band. Pile of legs more extensively pale, the black pile being limited to the lower posterior half and apices of the anterior four femora and the upper surface of the tarsi. In half the females there is no tawny abdominal pile, all the pile yellowish except for the black lateral areas on the third segment.

Type, male; *allotype*, female, and one male, seven females, Szechuen Province, China, (D. C. Graham). Types in U. S. N. M.

Rhingia lateralis n. sp.

Black; abdomen reddish with black lateral margins. Length, including snout, 12 to 13 mm.

Male.—Head black, the facial side pieces and a large, sub-triangular spot on the cheeks reddish; upper half of face, frontal orbits and the

occiput except above, greyish pollinose; pile black, pale around the posterior border of the oral opening; snout long, but little curved. Antennæ reddish brown or brownish red.

Thorax bronze black, moderately greyish pollinose, with three broad, bare vittæ; pile black, sometimes pale on hypopleura and sternopleura, the ventral scutellar fringe pale; no scutellar bristles, scutellum reddish.

Femora black, the apical third of the anterior four and fifth of the posterior pair, reddish; tibiæ reddish, with very broad, blackish median bands; tarsi brown, the anterior four more or less reddish basally. Pile black, yellow on posterior surface of hind femora.

Wings with brownish tinge, normal in shape; squamæ grayish white, with luteous border and yellow fringe. Halteres with brown knob.

Abdomen dark reddish, the first segment, a longitudinal, subtriangular basal spot on second, a median vitta on the third, the lateral margins and genitalia, black; apical sternite sometimes blackish. Pile yellowish; black on the immediate sides, on genitalia and in the middle of the apical two sternites except at their bases.

Female.—Front wide, thinly grey pollinose across the middle; black pilose; less pale pollen on mesonotum; scarcely any black pile on sides of abdomen.

Type, male; *allotype*, female; *paratypes*, two males, five females, Szechuen, China, (D. C. Graham). Types in U. S. N. M.

Key to the Indian Species of Criorhina.

1. Bumble-bee like species ..... 3.
   Apis-like species ..... 2.
2. Posterior femora with a distinct tooth-like process below near the base; face with median dark vitta ..... *dentata* Brunetti.
   Posterior femora simple; face without a dark vitta, shining brown on the lower half ..... *interrupta* Brunetti.
3. Face shining brown or black with a narrow pollinose vitta on either side ... 8.
   Face not shining brown ..... 4.
4. Tarsi wholly black or brown ..... 6.
   Tarsi with at least the first segment wholly reddish ..... 5.
5. All the tibiæ reddish yellow; posterior femora with a large, low swelling below near the apex and a rather gentle sub-basal swelling; posterior tibiæ normal (♂) ..... *pallidipes* n. sp.
   Posterior tibiæ mostly brownish, with a long, ventral excavation near the middle, their femora with a very large sub-basal swelling and without a pre-apical swelling below (♂) ..... *excavatus* n. sp.
6. Middle tibiæ ending in a spur (♂) ..... *imitator* Brunetti.
   Middle tibiæ not produced at the apex ..... 7.
7. Femora black haired (♀) ..... (?) *imitator* Brunetti.
   Femora yellow haired; spines at base of under surface of first segment of middle tarsi very long (♂) ..... *spinitarsis* n. sp.
8. Face shining black with greyish lateral vittæ (18 mm.) ... *simioides* Brunetti.
   Face shining brown with yellowish lateral vittæ (15 mm.) ..... *vivida* Brunetti.

Criorhina pallidipes new species.

Tibiæ and tarsi reddish yellow, the apical one or two tarsal segments brown; pile mostly yellowish. Length, 14 mm.

Male.—Face yellow in ground color; front and face densely golden yellow pollinose, the vertical triangle and occiput with greyish pollen; cheeks shining black. Antennæ reddish; arista brownish on apical half. Pile of head yellow, on the anterior half of the vertical triangle, black. Eyes contiguous for a short distance.

Thorax moderately greyish yellow pollinose, the pile yellow, with a weak, broad band of black pile on the posterior half.

Femora black, with the apices broadly reddish. Pile of the legs yellow, black on the under surface of the posterior femora which are conspicuously swollen postero-ventrally near the base and on the under surface near the apex, the tibiæ without apical spurs.

Wings cinereous hyaline; stigma brown. Squamæ whitish or cinereous. Halteres yellow.

Abdomen yellow pilose, the apex of the second segment broadly black haired except laterally; abdomen with greyish pollen except small basal triangles on the sides of the third segment.

Type, ♂, Deoban, Chakrata, India, Forest Entomologist's Collection, Dehra Dun.

Criorhina excavatus new species.

Mostly yellow pilose; tibiæ and tarsi reddish, the posterior tibiæ more than half brown, the apical two tarsal segments brown. Length, 14 mm.

Male.—Face reddish yellow in ground color; face and front golden yellow pollinose; cheeks shining black; occiput and vertical triangles with greyish yellow pollen; pile yellow, black on the anterior half of the vertical triangle. Antennæ reddish.

Thorax yellow pollinose and pilose, the posterior half of the mesonotum shining black and black haired except a narrow prescutellar fascia and the posterior calli.

Femora black; anterior four tibiæ with brownish post-median bands. Pile yellow, black on the upper surface of the anterior four femora, the upper surface of the posterior pair on the apical third, lower surface of posterior femora and on the apical two segments of the tarsi.

Wings cinereous hyaline, slightly brownish along the veins; stigma luteous. Squamæ greyish with yellow fringe, the upper lobe rather brownish. Halteres reddish.

Abdomen with greyish yellow pollen and yellowish pile, the apical third of the second segment except laterally, and the genitalia, shining black and black haired. Fifth sternite with short black hair.

Type, ♂, Deoban, Chakrata, India, in Forest Entomologist's Collection, Dehra Dun.

This species is readily separated from *pallidipes* by the shape of the posterior femora and tibiæ and the shining black genitalia of the male.

Criorhina spinitarsis new species.

Similar to *imitator* Brunetti but the middle basitarsus bears six or seven spines sub-basally, each of which is longer than the thickness of the tarsus, and the femora are yellow pilose. Length, 21 mm.

Male.—Face and front greyish yellow pollinose, the cheeks, front of antennal prominence and the vertical triangle shining black, the latter thinly pollinose; pile yellowish, rather whitish on the lower part of the occiput. Antennæ black, the third segment missing. Eyes rather narrowly separated. Face strongly produced downwards.

Thorax with long yellow pile and yellowish pollen, the posterior half of the mesonotum, except a narrow prescutellar fascia, shining black and black haired.

Legs black; pile yellow, very short on the tibiæ and tarsi, rusty reddish on the lower surface of the tarsi, mostly blackish above. Middle and posterior tibiæ not produced; posterior femora moderately large; claws red on basal half.

Wings cinereous hyaline, with brownish tinge along the veins. Squamæ brownish, the lower lobe whitish with brown border. Halteres brown.

Abdomen black; first two segments with yellow, third with black, the fourth with long, tawny pile, the genitalia mostly tawny pilose, some of the hair black. Venter yellow pilose, the fifth sternite with short black pile except at the sides.

Type, ♂, Rishikesh, Dehra Dun, India, Dec. 18, 1918, in Forest Entomologist's Collection, Dehra Dun.

Mallota salti n. sp.

Black, clothed with yellow and black pile; scutellum and tarsi reddish; wings brown with pale apex and posterior border. Length, 12 mm.

Female.—Anterior fourth of front, broad median facial vitta and anterior half of cheeks shining brown; face and occiput yellowish grey pollinose; front opaque black; pile of head wholly black. Antennæ black; third segment and arista reddish, the arista brown on basal fourth.

Thorax black pilose, the dorsum on the anterior half with reddish yellow pile, the upper part of the mesopleura similarly clothed, beneath the pale pile greyish pollinose, with obscure dark median vitta. Scutellum yellow pilose.

Legs brown; femora apically, broad bases and apices of the tibiæ and the front tarsi reddish brown; middle and hind tarsi reddish; pile black.

Wings brown, the very broad apex and broad posterior border cinereous hyaline. Marginal cell broadly open.

First abdominal segment, base of second, apex of third and base of fourth, black pilose, the black pile triangularly produced forwards in the middle on the third segment and widening laterally on the fourth. Venter with yellow pile except on the basal sternite.

The pile in this species is somewhat longer than in *posticata* Fabricius.

Holotype, female, Vista Nieve, Santa Marta, Columbia, 5000 ft., February 10, 1927, (G. Salt), in Curran Collection.

Related to *M. margarita* Williston, and with almost similarly colored wings, but *margarita* lacks yellow pile on the thorax.

Mesembrius simplicipes n. sp.

Related to *platytarsis* Curran, but at once distinguished by the simple hind tarsi. Length, 13 mm.

Male.—Head golden yellow pollinose, the cheeks with paler pollen; pile golden yellow, black on the vertical triangle. Vertical triangle and a rectangular spot above the antennæ black, the latter with a few black hairs; eyes touching for a short distance; antennæ brown, the basal segments tinged with red.

Mesonotum dull black, with the lateral margins and two broad vittæ reddish gray, the vittæ broadly fused behind; the pleura mostly grayish pollinose. Pile reddish yellow, the lateral black areas behind the suture with coarser black hair, the disc of the reddish scutellum bearing short black hair.

Legs reddish; a broad stripe on the anterior femora above and the hind femora on basal three-fourths, black. Anterior femora broad, bearing short, black hair dorsally, laterally and posteriorly with rather short golden yellow pile, ventrally with dense, long golden reddish pile, the black hair becoming long posteriorly. Anterior tibiæ broad except basally, with a large black spot on apex of under surface in front, two conspicuous tubercles situated in the black spot; the golden reddish pile is long and dense posteriorly, elsewhere short, on the black spot very short and black; in some lights this spot appears cyaneous. Anterior tarsi broad, the first segment wider than long, the posterior edge strongly produced, the segment mostly whitish; second segment produced on anterior apex, longer than wide, much narrower than first; third as long as wide; fourth twice as wide as long; hair black on dorsum of apical two or three segments, tawny on the sides and on basal segments. Middle femora robust, tapering on apical third, pale haired except on apical two-thirds of under surface; middle tibiæ strongly arcuate on apical two-thirds, black haired ventrally, the hair long on

basal third, elsewhere with rather short, golden reddish pile; middle tarsi black haired. Posterior femora rather strongly thickened, tapering on apical third; black haired on apical third, expanding to half below, a few scattered black hairs extending to basal third, the ventral black hair coarse. Posterior tibiæ arcuate, black haired, the hair dense and erect ventrally, a few pale hairs postero-dorsally. Posterior tarsi black haired. All the tarsi become blackish apically.

Wings cinereous hyaline, the squamæ, their fringe and halteres yellow.

First abdominal segment black, gray pollinose; second with a broad median vitta, a broad, laterally tapering posterior fascia and a narrow, incomplete basal fascia black, opaque except the broad apex. Third segment black, with a pair of large, subrectangular, broadly separated basal reddish spots which reach the lateral margin in full width and are connected in front by a broad, gray pollinose fascia and narrowly so behind, bearing a roundish opaque black spot a little before the middle of the segment; behind the second pollinose band the segment is thinly grayish pollinose. Fourth segment with the basal half on the median two-fifths yellowish gray pollinose, the pollen enclosing a small, roundish opaque black spot. The pile is reddish yellow, only black on median half of the black posterior fascia on second segment, and on median fifth of black fascia on third segment; it is dense and erect on the fourth segment, especially towards the apex.

Type, male, Great Oriental Forest, Madagascar, in California Academy of Sciences.

Mesembrius platytarsis n. sp.

Related to *tarsatus* Big. and *perforatus* Speis, from both of which it differs in the simple posterior tibiæ. Anterior tarsi flat, broad, the first segment of the posterior pair more than twice as wide as following segments, deeply excavated on the anterior apex, the anterior corner of which bears a long, mammiform projection. Length, 13 mm.

Male.—Face yellowish white pollinose, the head elsewhere golden yellow, but the pollen becomes paler on the lower occiput; facial vitta, a spot on the frontal triangle anteriorly and the ocellar region, black. Pile yellowish, black on frontal and vertical triangles the sides of the former broadly pale pilose; antennæ brownish black.

Thorax dull black; pleura yellowish gray pollinose; mesonotum with two broad, widely separated vittæ and the lateral margins reddish yellow, the median vitta connected posteriorly by a broad, more grayish band in front of the scutellum. Scutellum reddish with blackish base. Pile reddish yellow, mostly black on the mesonotum behind the suture, and on the scutellum except the border.

Legs reddish, anterior femora with a median black streak above, the posterior pair black except on apical fourth, the tarsi becoming

ferruginous apically. Front femora broad, much wider than high, their posterior edge almost evenly convex; the pile golden reddish and fairly long postero-ventrally, elsewhere black, very short above; front tibiæ rather broad, wholly golden reddish pilose; front tarsi broad, flat, the first segment whitish, sub-triangular, as long posteriorly as wide, anteriorly with three or four basally curved bristly hairs, and beneath with several brown ones, second segment as long as wide, the following two much shorter than wide; hair reddish laterally, black above. Middle femora swollen, on apical third of hind and apical half of front surface with short, black hair, that behind long above, elsewhere yellow pilose; middle tibiæ yellow pilose, the under surface with short, black hair, their tarsi black haired. Posterior femora swollen, scarcely curved, pale haired, the apical third with black hair; no coarse black hair basally; hind tibiæ compressed, simple, with short, black hair; hair of hind tarsi black. The middle tibiæ are rather strongly arcuate on the apical two-thirds, the concavity beneath.

Wings grayish hyaline. Squamæ and fringe yellow; halteres reddish yellow.

First abdominal segment black, gray pollinose; second segment reddish yellow, with a broad median vitta, the rather broad base on the median half and the fairly wide apical margin, black, opaque except the narrow apex, the black narrowing laterally. Third segment shining black on apical third and with a broad, opaque black median vitta. Fourth segment grayish yellow pollinose on basal half, the sides broadly and the apical half shining brown, a small oval median spot in the pollen opaque black. The pile is yellowish, black on the black posterior fasciæ on the second and third segments, on the median vitta on the third and on lateral triangles which project forwards half way to the anterior corners on the second.

Female.—Front black pilose on whole length, pale pilose on sides of lower half; legs almost simple, the front femora only a little widened, the hind pair not as large as in male, pile as in male on front legs, wholly pale on middle femora and tibiæ and mostly pale on hind tibiæ. More than the lateral third of the basal two-fifths of the fourth segment is yellow; the third segment is gray pollinose on the median third behind the black vitta while the fourth bears an incomplete gray pollinose fascia behind the pale spots, but not touching them; fifth segment gray pollinose on basal three-fifths with a brown median spot; the second to fourth segments have the black fasciæ black pilose while the third and fourth are broadly black haired in the middle.

Holotype, male; *allotype*, female; Great Oriental Forest, Madagascar, in California Academy of Sciences.

Sericomyia completa n. sp.

Black, the thorax shining; abdomen with three narrow, entire, orange bands. Length, 17 mm.

Male.—Face perpendicular, the tubercle low but conspicuous; more than the lateral third of the face pale yellowish, the lateral fourth whitish pollinose; cheeks, occiput and front with cinereous pollen, the pile pale yellowish, black on frontal and ocellar triangles; occipital cilia black. Antennæ reddish brown, rays of arista black.

Thorax pale yellowish pilose, the pile much more conspicuous laterally and on the pleura; a broad band of black pile between the wings, the scutellum black pilose except on the border.

Coxæ and femora black, the broad apices of the latter and the tibiæ and tarsi reddish, the apical two or three tarsal segments brown, black haired. Posterior trochanter with angulate tubercle. Pile of legs pale. Posterior tibiæ conspicuously swollen, gently arcuate, their tibiæ more strongly curved.

Wings luteous anteriorly, rather brownish on apical third in front, hyaline behind, veins reddish. Squamæ whitish, their cilia brown. Halteres brown, with reddish stem.

Abdomen with three entire pale orange faciæ which do not quite reach the lateral margins, are very slightly bowed forward, the band on the second segment obscurely interrupted by a slender line, the bands all of the same width, about one-fifth as wide as the length of the third segment, and successively closer to the base of their respective segments, that on the third segment about its own width from the base. The pile is pale yellowish, the second and third segments each with a broad, incomplete band of black pile occupying the posterior third or more.

Type, male, Kiluno, Formosa, in California Academy of Sciences.

Key to the Species of Korinchia Edwards.

1. Scutellum wholly reddish in ground color ..... *rufa* H. B.
   Scutellum black in ground color, the border yellow or brown ..... 2.
2. Scutellum clothed with abundant appressed golden hair, the posterior border with several long, brown hairs ..... *aurata* H. B.
   Scutellum largely black haired or the pile erect and sparse ..... 3.
3. With a patch of yellow hair outside the posterior calli ..... 4.
   With only dark hair outside the posterior calli ..... *monticola* Edw.
4. Pile of scutellum largely blackish ..... 5.
   Pile of scutellum wholly yellowish except for a few long brown hairs on the margin ..... *sinensis* n. sp.
5. Fourth abdominal segment with a large, yellowish-gray patch on either side ..... *klossi* Edw.
   Fourth abdominal segment without greyish patch ..... *robinsoni* Edw.

Korinchia sinensis n. sp.

Female.—Length, 13 mm.; face reddish in ground color, with a median brown vitta tapering above, wholly golden yellow pollinose; a vitta on the cheeks shining brown; supra-antennal shining brown spot rectangular; pollen of upper three-fourths of front and upper fourth of occiput brownish; pile of front and upper fourth of occiput black, elsewhere, yellow. Antennæ reddish, the basal two segments brownish red.

Thorax black; mesonotum with brownish ochreous pollen in front of the suture; humeri and a stripe running over the mesopleura golden yellow, the sutural fascia not much paler than the mesonotal pollen; pollen of the pleura greyish. Pile of thorax brassy yellow, not abundant, black on the mesonotum behind the suture and on the sides in front; scutellar pile yellowish with a few scattered black hairs apically, the border of the scutellum broadly yellow and yellow pollinose.

Legs reddish, the tibiæ yellow on basal half or more; anterior tibiæ black on anterior surface and on apical sixth, their tarsi wholly black; hair golden yellow except on black parts and apical one or two segments of the tarsi, the femora with some short black hairs apically on under surface.

Wings cinereous hyaline, with a grey cloud apically and a narrow, weak greyish fascia across the middle. Squamæ greyish, with brown border and yellow fringe; halteres yellow.

Abdomen rusty reddish, the second to fourth segments each with a brown median spot basally, that on second and third segments subrectangular, on the fourth, roundish. Pile pale golden yellow, black on the fifth segment and on the apex of the fourth, much more widely so in the middle, and a few scattered black hairs on the apex of the third; pile appressed, the pale hair fine. Sternites black with yellow posterior borders, the pile black on the apical two, elsewhere pale, wholly short and appressed.

Type female, Suifu, Szechuen, China (D. C. Graham), in U. S. N. M. *Paratype*, female, near Washan, Szechuen, China, 7–9000 ft., July 21, 1925 (Graham).

TACHINIDÆ.

Signosomopsis townsendi n. sp.

Abdomen dark reddish with black median vitta and six pairs of white pollinose spots; legs reddish and yellow, wings brown. Length, 11 to 14 mm.

Male.—Head black, the face and cheeks yellow, head pale yellow pollinose, the front with less abundant greyish pollen; frontal vitta reddish. Hair of front, parafacials and upper part of cheeks, black, elsewhere yellowish. Front five-sixths as wide as eye; no ocellars; eight to ten pairs of frontals and two or three in a secondary row below; vertical bristles cruciate; outer verticals long; occipital cilia extending to lower fifth of eyes. Antennæ reddish, third segment black, about as long as the second; penultimate aristal segment three or four times as long as wide. Palpi represented by a bristle.

Thorax greyish pollinose, with olivaceous tinge above; the vittæ slender; scutellum reddish. Acrosticals 2–3; dorsocentrals 3–3; three intra-alars; sternopleurals 2–1; scutellum with two pairs of marginals and a very weak, cruciate apical pair, the disk with coarse, fairly abundant bristles and short hair; propleural hair black.

Femora reddish; tibiæ and tarsi very pale yellowish.

Wings brown; squamæ milky-white, the upper lobe with brown border. Halteres reddish, with brown knob.

Median black vitta of abdomen broad, not reaching the apex of the abdomen, the second to fourth segments each with a rather narrow basal white pollinose fascia which becomes weak laterally and widens on the venter, these segments each with a sub-triangular or sub-oval, white pollinose spot on either side of the vitta, the spots on the second segment reaching the apex of the segment. Hair black; second and third segments each with six to eight discal bristles forming an arched row in front of the middle, second segment with the marginal row interrupted on either side of the middle, the row on the third segment entire; fourth segment with bristles on a little more than the apical half, the bristles becoming weaker towards the apex of the segment; sternites with bristles. The abdominal bristles are strong but not blunt. Genitalia reddish.

Female.—Differs only sexually: Front one-fifth wider than eye; two pairs of orbitals; penultimate aristal segment two or three times as long as wide.

Holotype, male, Matucana, Peru, 8000 ft., on foliage, Aug. 16, 1913, (C. H. T. Townsend), in United States National Museum.

Allotype, female, same data.

Paratypes, ten females, same data; four females, Jan. 29, 1913; two females, Sept. 8, 1912; female, "Bogota," in Canadian National Collection.

Signosomopsis eronis n. sp.

Abdomen reddish with broad median black vitta and rather narrow white pollinose fasciæ on bases of segments; legs reddish, the tarsi yellow. Length, 12.5 to 13.5 mm.

Male.—Face and cheeks yellow; head white pollinose, hair black, the occipital pile yellow; frontal vitta brownish; six to nine pairs of frontals, the upper pair divergent; cheeks one-half as wide as eye-height. Antennæ brownish red, third segment black, large; basal aristal segment short, the penultimate segment from three to five times as long as wide. Proboscis black, the palpi represented by a small bristle. Hair of parafacials black, of cheeks largely yellow.

Thorax with greyish pollen, that on mesonotum with ochreous or olivaceous tinge, in some lights brownish red posteriorly, the vittæ weak; hair black. Acrosticals 0–1; dorsocentrals 3 or 2–3; three pairs of marginal scutellars and a pair of weak, cruciate apicals, the dorsum with a few short, spinous bristles; sternopleurals 1–1–1. Scutellum brownish red.

Femora and under surface of tibiæ black haired, the hair elsewhere yellow; tarsal bristles yellow.

Wings brownish, darker basally. Squamæ brown; halteres brownish red.

The pollinose abdominal fasciæ are obsolete laterally, but on the fourth segment the whole segment may appear pale yellowish pollinose from some views; the black vitta usually does not reach the apex of the abdomen. Second segment with a cluster of about eight pairs of spinose discals, the third with an arched row of about four pairs; fourth segment with bristles except basally. Bristles of sternites rather obtuse apically; lobes of fifth sternite brownish; genitalia reddish.

Female.—Hair of cheeks mostly yellow, of the tibiæ, black; differs only sexually.

Holotype, male, Ollachea, Peru, Feb. 2; *Allotype*, female, Uruhuasi, Peru, Feb. 15. *Paratypes*, male, two females, Uruhuasi, Feb. 3, 5, 1910, (C. H. T. Townsend). Types in U. S. N. M.

Dexodes nana n. sp.

Black, halteres yellow, the pollen cinereous. Length, 5.5 to 6 mm.

Male.—Pollen of head with silvery tinge, the parafrontals almost bare above, about fourteen pairs of frontals, the upper three reclinate, the two lower reclinate pairs strong; ocellars strong; outer verticals very weak. Front three-eighths as wide as either eye; the parafrontals about as wide as frontal vitta. Occipital pile white; cheeks black haired, two-ninths as wide as eye-height, parafacials narrowing below, at the middle much narrower than third antennal segment; four or five bristles immediately above the vibrissæ. Palpi black. Antennæ black; third segment moderately wide, the upper apex angular, lower apex rather sharply rounded. Arista thickened on basal fifth.

Pollen of thorax rather thin, especially on the mesonotum, the vittæ not conspicuous. Acrosticals 2–3; dorsocentrals 2–3; posterior sub-lateral absent; posthumeral weak three pairs of marginal scutellars and a pair of apical hairs; three sternopleurals. Hair of thorax black.

Legs black; middle tibiæ with a single antero-dorsal bristle; pulvilli elongate.

Wings with cinereous tinge, the base somewhat luteous; third vein with two or three weak basal bristles. Squamæ white; halteres yellow.

Basal two-fifths of second to fourth abdominal segments whitish pollinose, the pollinose bands broadly interrupted in the middle. First segment with pair of marginals, the others each with a row; second segment with one or two pairs of discals, third with an irregular row, the fourth with two rows.

Female.—Front a little more than half as wide as eye, two pairs of orbitals eight or nine pairs of frontals, the upper two pairs reclinate; outer verticals distinct. Pollen of front and thorax thicker. Pulvilli

short, second abdominal segment with one pair of discals, the row on the third segment not always complete.

Holotype male, *allotype* female and several additional specimens from Kaslo, B. C., June and July, 1903, (R. P. Currie), in United States National Museum. Paratypes in Canadian National Collection.

Key to the Australian Species of Prosena.

1. Scutellum wholly dull black ..... 2.
   Scutellum pale pollinose or pale in color ..... 4.
2. Mesonotum with a broad, brown fascia behind the suture, otherwise pale pollinose (from posterior view) ..... 3.
   Mesonotum black vittate ..... *vittata* Macquart
3. Wings brownish on the apical half, paler brownish on basal half, *argentata* Curran
   Wings almost hyaline (Tasmania) ..... *rufiventris* Macquart
4. Femora reddish or yellowish on at least the basal half ..... 5.
   Femora black ..... 10.
5. Abdomen without a median shining black vitta ..... 6.
   Abdomen with the median vitta shining black ..... *dorsalis* Macquart
6. Cheeks wholly white pollinose, without a reddish brown spot between the eye and oral margin ..... 8.
   Cheeks with a reddish brown or dark spot extending from the eyes to the oral margin ..... 7.
7. Mesonotum with an incomplete brownish fascia behind the suture, *bella* Curran
   Mesonotum vittate ..... 13.
8. Mesonotum with fine, yellowish hair ..... *sibirita* Fabricius
   Mesonotum with only coarse black hair, except on the sides ..... 9.
9. Parafacials with distinct yellowish hair; front with black hair ..... *facialis* Curran
   Parafacials without any trace of hair; front with sparse yellowish hairs inwardly ..... ♂♀ *malayana* Townsend; ♀ *siberita* Fabricius
10. Legs wholly black; pleura pale pollinose ..... 11.
    Tibiæ reddish; mesopleura black pilose ..... *varia* n. sp.
11. Mesonotum pale pilose; legs very long ..... *zonalis* n. sp.
    Mesonotum black haired ..... 12.
12. Scutellum wholly dark in ground color ..... *nigripes* Curran
    Scutellum reddish ..... *scutellaris* n. sp.
13. Tibiæ brown; frontal vitta black (Tasmania) ..... *dispar* Macquart
    Tibiæ reddish; frontal vitta rusty reddish (Australia) ..... *variegata* n. sp.

Prosena scutellaris, new species.

Black, the head and the basal three abdominal segments, except a median vitta, yellowish; pollen thick, cinereous, not tessellate. Length, 10 mm.

Male.—Head whitish pollinose, the occiput greyish, black in ground color, the front with yellowish tinge, the vitta rusty reddish. Front half as wide as either eye; eight pairs of frontals; ocellars long; occipital cilia extending to lower sixth of the eye; pile of occiput and cheeks yellowish, the latter with pile in front. Proboscis not quite twice as long as head-height. Antennæ yellowish; arista reddish brown.

Thorax with cinereous pollen dorsally, grey on the pleura; mesonotum black haired, the pleura yellowish pilose. Humeri and scutellum red-

dish. Dorsocentrals 2–3; sternopleurals, 1–1; three pairs of marginal scutellars and a pair of discals.

Legs black, the knees reddish; middle tibiæ with a fairly strong antero-dorsal bristle.

Wings cinereous hyaline, with luteous tinge anteriorly. Squamæ whitish with yellow border; halteres yellowish.

Median abdominal vitta broad, the fourth segment obscurely reddish laterally on its broad base. Abdomen almost evenly, coarsely cinereous pollinose, each segment with a transverse, bare, dark apical spot on either side. First segment without marginals, second with one pair, third with row of six, the fourth with eight. Abdomen with black hair except on the base of the venter.

Type, ♂, Neu Brittannia, in Zool. Mus. Hamburg.

Prosena zonalis, new species.

Black, the abdomen with two or three broad, interrupted yellow fasciæ; mesonotum silvery from anterior view, with four vittæ which form a large, indefinite dark area behind the suture, from posterior view . Length, 9.5 to 10.5 mm.

Male.—Head yellowish, the occiput black in ground color, white pollinose, the occiput more greyish. Nine or ten pairs of frontals; occipital pile sparse, yellowish. Cheeks two-ninths as wide as eye-height, yellow haired; face and cheeks separated by a broad rusty brownish stripe. Proboscis one-third longer than head-height. Antennæ reddish. Front two-sevenths as wide as either eye.

Thorax densely greyish white pollinose, yellowish pilose. Scutellum black with reddish apex, clothed with grey pollen and black hair. Dorsocentrals, 3–3; sternopleurals 1–1; three pairs of marginal scutellars, the apical pair cruciate.

Legs very long, black; coxæ silvery grey pollinose.

Wings cinereous hyaline, somewhat brownish on the apical half, conspicuously so in front. Squamæ white; halteres yellow.

Abdomen opaque brown, the basal three-fifths of the second and third segments yellowish except for a median vitta, the pale areas and the fourth segment except its tip, silvery greyish pollinose. First segment without dorsal bristles, the second with a pair, the third and fourth each with a row of marginals. Hair black on the dorsum, yellowish on the under part of the first three segments and on the yellow pollinose genitalia.

Female.—Front four-fifths as wide as either eye, with two pairs of orbitals and a few obscure, yellowish hairs; dark mesonotal vittæ appearing brownish; fourth abdominal segment reddish on the basal half; legs shorter; mesonotum black haired.

Holotype, ♂, allotype, ♀, and 3♂ paratypes, Tonga. Types in Zool. Mus., Hamburg.

Prosena variegata, sp. n.

Black, the abdomen chiefly reddish, legs reddish, tarsi black; wings cinereous or brownish hyaline. Length, 10 to 12 mm.

Male.—Head reddish, the occiput black; pollen whitish, on the occiput above and on the front with yellow tinge; nine or ten pairs of frontals with yellow hairs between them; frontal vitta brownish red, obsolete above; ocellars long; the black occipital cilia extend almost to the lower edge of the eyes; pile of the occiput and cheeks yellowish, distinct on the anterior part of the cheeks; cheeks almost one-third as wide as eye-height, with rusty band across the middle. Proboscis one-seventh longer than head-height; antennæ orange; arista brown.

Thorax grey pollinose, with ochreous tinge dorsally and with four distinct vittæ; humeri largely reddish; scutellum reddish on apical half; pleura pale pilose, the mesopleura about half, the humeri and dorsum black haired. Dorsocentrals 3–3; sternopleurals, 1–1; 3 pairs of marginal scutellars, no discals.

Legs very long, reddish, the tarsi black. Squamæ whitish. Halteres reddish.

Abdomen reddish, the depression and sides of the first segment, a median vitta, a broad lateral band on the second segment, the apical fourth of the third and the whole of the fourth, black, the pollen rather abundant, tessellate, whitish, covering almost all the fourth segment, the other black areas opaque except the median vitta which is pollinose on the anterior three-fourths of each segment and shows a brownish pollinose median line. First segment with a pair of long marginals, the second with six, the median pair of which is well separated from the others, the third and fourth segments each with a row of marginals. Hair sparse, black, yellow on the basal half of the venter; genitalia grey pollinose.

Type, ♂, Gravesend, Queensland, 15.v.1925 (J. Mann); paratypes: ♂, same data and ♂, Australia, (Schrader).

Prosena varia, sp. n.

Rather slender; black, face and cheeks yellow; sides of the basal three abdominal segments reddish; mesonotal vittæ rather weak; legs black, the tibiæ reddish. Length, 9 mm.

Male.—Head white pollinose. Front one-fifth as wide as either eye; ocellars long and strong; nine or ten pairs of frontals; some long black hair above; the occipital cilia extend as a row of fine hairs across the cheeks; pile of the occiput and cheeks yellow, the latter without hair in front, with an orange stripe across the middle. Proboscis more than one and one-half times as long as head-height. Antennæ orange; arista brown basally, its rays brown.

Thorax ashy pollinose, the four vittæ distinct from posterior view; hair of the mesopleura, humeri and dorsum black; scutellum wholly dark; pile of pleura yellow. Dorsocentrals, 2 or 3–3; sternopleurals, 1–1; 3 pairs of marginal and a pair of discal scutellars, the hair of the scutellum long.

Legs blackish, the tibiæ reddish. Wings with brownish tinge. Squamæ slightly greyish, with yellow border. Halteres reddish.

Basal three abdominal segments with a very broad median black vitta, the sides reddish, the second segment with narrow, the third with broad posterior border brownish or black, the whole abdomen rather thickly cinereous pollinose, the apices of the segments broadly sub-shining on the sides, the pollen sub-tessellate. First segment with a pair of long marginals, the second with stouter pair, the third and fourth segments each with a row. Hair black, yellow on the venter of the basal two segments. Along the broad middle line the pollen has a strong brownish cast.

Type, ♂, New South Wales, (Schrader).

DESCRIPTIONS OF NEW OR INADEQUATELY KNOWN AMERICAN SPIDERS.

(Second Paper).*

ALEXANDER PETRUNKEVITCH,
Yale University.

Order **MYGALOMORPHAE**

Family **Ctenizidae**

Pachylomerus carabivorus Atkinson.
(Plate I, Figs. 1 to 9).

(a) *Female* from Rome, Georgia, collected by Mr. H. B. Bilbro in March, 1918.

Total length with cheliceræ 27.0 mm. *Carapace* 10.0 mm. long, 9.0 mm. wide, narrower behind than in front and almost hexagonal in shape (Pl. I, Fig. 1). Thoracic groove procurved, semicircular, deep; the vertex of the semicircle exactly ⅓ from posterior margin. The head slopes steeply toward the groove. Posterior border of groove evenly rounded, anterior border rather angular. Neither cephalothoracic sulcus, nor the radiating thoracic sulci well developed, yet clearly indicated by the darker color of the chitin. A narrow band of chitin around entire margin of carapace quite white. Surface of carapace glabrous, with black bristles only in the following places: a tuft of about 18 bristles in front of AME, the four stoutest forming the usual transverse row; Irregularly arranged bristles filling the space between AME and PME; a row of middorsal bristles beginning at the anterior edge of the eyetubercle and extending back to about half the distance to the thoracic groove; this row is accompanied by flanking bristles in its anterior portion, but further back consists entirely of a single row. Finally, a pair of lateral bands of bristles extending on each side from the posterior eyes back as far as the middorsal row, but slightly diverging and composed of from 2 to 4 bristles abreast.

Eyetubercle rather low, short and wide, with the PME alone on the level of the surface of the tubercle. These eyes are of the nocturnal type. AME are raised on a joint tubercle of their own and each lateral eye is situated on a tubercle of its own. (Fig. 2). Eyetubercle 0.935 mm. long, 1.955 mm. wide. First row of eyes procurved, second row slightly, but distinctly recurved and a little longer. Ratio of eyes AME : ALE : PME : PLE = 7 : 12 : 9 : 11. AME separated from each other by ⅝ of their diameter, from ALE by ⅞ of their diameter, from PME by ⅝ of their diameter, from edge of clypeus by ²⁄₇ of their diameter. PME separated from each other by ⅞ of their long diameter,

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from PLE by ⅛ of their long diameter. Laterals separated from each other by $^{16}/_{12}$ of the diameter of ALE. Quadrangle much wider behind than in front in ratio 41 : 23, wider than long in ratio 41 : 22. A straight line passing through the centers of the AME and PLE of the same side touches the anterior edge of the PME (Pl. I, Fig. 2). A straight line passing through the ALE of one side and the PLE of the opposite side cuts also the AME of the same side with the ALE and the PME of the opposite side, though not through their centers (Pl. I, Fig. 2).

Cheliceræ powerful, curved in front, flat on prolateral surface. A longitudinal band of bristles, beginning with a single bristle opposite ALE runs widening toward the distal end of the basal joint. Another, narrower band begins with a single bristle at base of cheliceræ in middle of outer surface, half way distally begins to widen and merges with the apical area of bristles before the rastellum. A third row of bristles, single file, begins near base almost on outer visible edge and merges distally with the apical area. Rastellum well developed, composed of numerous short stout spines. It begins about ¼ the width of the fang from its retroarticulation. In middle a regular projection is formed, extending to proedge of cheliceræ (Pl. I, Fig. 3). Promargin with a somewhat irregular row of teeth of different size. There are 8 teeth on the left and 10 on the right chelicera, the extra two being proximal and very small. Retromargin with a row of 6 more or less equidistant and equal teeth. Scopula on both margins, but rather light. *Lip* wider than long in ratio $^{23}/_{17}$, narrowed in front where its truncated edge measures only $^{11}/_{23}$, i.e. about one-half its greatest width. The lip is convex longitudinally and transversely and is separated from the sturnum by an almost semicircular sulcus, but a suture is not present, the lip being immobile. At the end of the lip a group of about 14 cuspules is situated, each cuspule in its own socket. Surface of lip clothed with more or less evenly spaced black bristles.

Coxæ of *pedipalpi* devoid of maxillary processes and the trochanter is inserted at the end of the coxa. A band of black cuspules extends from basal proangle diagonally to middle of coxa. Small brown cuspules cover distal end of coxa changing gradually into short bristles as they reach middle of coxa. Surface in front of black and brown cuspules is occupied by the scopula which is composed of fine, soft, brown hair without any definite arrangement. Long bristles clothe the base of the coxa, while the surface facing the first coxa is quite smooth. *Sternum* slightly longer than wide in ratio 70 : 62, widest between second and third coxæ, narrowed in front to width of lip, pointed behind. Sigilla wanting, but immediately behind lip a band of modified chitin extends across entire sternum, in a curve. Sternum sparsely clothed with black erect hair along the edge, but is almost free from hair elsewhere.

First pair of *coxæ* longest and more slender than the others, being twice as long as wide. Third coxæ shortest, measuring only a little more in length, than in width, the ratio being 37 : 30. All coxæ sparsely clothed with hair, those of the first pair entirely so, those of the second pair have a small bald spot near base; those of the third pair have two

large bald spots separated from each other by a longitudinal band of hair. Fourth coxæ similar to the third pair and are contiguous. *Trochanters* of palpi present in apical half, below, a somewhat raised, yellow area clothed with bristles many of which are modified as elongated, sharppointed cuspules. Trochanters of first and second pair of legs have a similar raised area, though of smaller size and clothed only with black bristles. Third and fourth trochanters are clothed with curved hair near apex. Above, third trochanters have a chitinous hook which is not quite middorsal in position and is directed toward the carapace. Fourth trochanters are peculiarly compressed at their proximal end. Third and fourth *femora* are much heavier than the others and almost naked below, while the other femora are clothed with erect, stiff, black hair. Above, all femora have a middorsal and two lateral bands of black, stiff hair, leaving between them two longitudinal, bald areas.

First and second *patellæ* are similarly clothed above. Patellæ of palpi are clothed in the same manner, but have in addition three or four cusps on inside near apex. Fourth patellæ have a longitudinal middorsal bald area and are covered with cuspules which change gradually into bristles toward apical end of joint. Third patellæ have two longitudinal bald areas and in addition to the black bristles have short spines or cuspules on prolateral surface.

Tibiæ of palpi as well as first and second tibiæ have two longitudinal bald bands and are densely covered laterally with peculiarly modified spines shown in Fig. 4. Similar spines cover the sides of first and second metatarsi and tarsi and of the terminal joint of palpi. Third tibiæ above with the saddle-like excavation peculiar to the genus and are covered at distal end with short, stout, blunt spines. Third metatarsi are almost entirely covered above with similar spines, while on the tarsi there are only a few spines above and below. Third tibiæ have a pair of ventral apical spines of the normal type. Fourth tibiæ have two longitudinal dorsal bald bands and are clothed on prolateral surface above with long hair, lower down with common spines which extend almost to ventral mid-line. Fourth *metatarsi* have a single dorsal bald spot near base and are clothed with common short spines prolaterally down to midventral line. Fourth *tarsi* have prolaterally similar spines and below long stiff hair not definitely arranged. Claws three; upper claws similar, with a single tooth (Pl. I, Fig. 5). Third claw smooth. Palpal claw with a large tooth and a much smaller one between the latter and the end. (Pl. I, Fig. 6). *Legs* 4132.

	Femur	*Patella*	*Tibia*	*Metatarsus*	*Tarsus*	*Total*
I	5.610	3.910	3.570	2.550	1.785	17.425
II	5.270	3.825	2.975	2.380	1.785	16.235
III	4.930	3.570	3.400	2.465	2.295	16.660
IV	6.800	4.165	3.995	3.825	2.295	21.080
Palp	5.525	3.230	3.570	2.975		15.300

Abdomen finely mottled above and below with little pimplelike elevations for each individual hair, and with numerous small bald areas between. *Spinnerets* four, situated almost in a row. Anterior

pair slender, short and single-jointed, not quite as long as basal joint of posterior spinnerets. These are much heavier, three-jointed with joints shorter than their diameter. Terminal joint small, hemi-spherical. Small spinning tubes cover entire tip of anterior spinnerets, while a single large spigot is situated in the center of their truncature. In the posterior spinnerets small spinning tubes cover a ventral segment of the basal joint, entire ventral surface of the second joint and the entire terminal joint. Large spigots on the posterior spinnerets are distributed as follows: on the basal joint four in a transverse row at apex; on the second joint five in an apical transverse row, five in a median transverse row and a single prolateral, or eleven in all; on the terminal joint a single spigot. There are therefore altogether 4 + 11 + 1 = 16 large spigots on each posterior spinneret. *Color* in alcohol: dark brown with dark grey abdomen. Below lighter, with the four lungs and the spinnerets yellowish brown.

(b) *Female* from Dead Run Swamp, Va., near Plummer Island, collected by H. S. Barber on April 10, 1917, a few inches under the ground in a nest with numerous young.

Total with cheliceræ 16.7 mm. *Carapace* 7.225 mm. long, 6.460 mm. wide. Thoracic groove slightly more than two-thirds from anterior margin. A few bristles in front of eyegroup and those behind it in single rows. *Eyegroup* shown in Pl. I, Fig. 7, almost rectangular, one and one-half times as wide as long. First row of eyes not quite as long as second. A line passing through the centers of ALE and PLE of the opposite sides cuts AME of the former and almost touches anterior edge of PLE of the latter. Ratio of eyes AME : ALE : PME : PLE = 8 : 15 : 8 : 13. AME separated from each other by $\frac{5}{8}$ of their diameter, from ALE by $\frac{1}{8}$ of their diameter, from PME by $\frac{5}{8}$ of their diameter, and from edge of carapace by $\frac{24}{8}$ of their diameter (i.e. by three diameters). PME are separated from each other by $\frac{15}{8}$ of their long axis, from PLE by $1\frac{5}{8}$ of their long axis. Laterals are separated from each other by $\frac{5}{8}$ of the diameter of AME. Quadrangle wider behind than in front in ratio 30 : 22, wider than long in ratio 30 : 21. *Trichobothria* on all tarsi in two rows, a few trichobothria on metatarsi and a single one on the saddle of the third tibia. Club-shaped hairs on tarsi present. Retrolateral spines on fourth tarsi arranged in an oblique row. Hooks on anterior legs and palpi arranged more regularly. Lip with only four cusps.

(c) *Female* in my own collection, locality unknown.

Total with cheliceræ 29.0 mm. Carapace 11.8 mm. long, 10.5 mm. wide. Eyegroup wider than long in ratio 78 : 37, i.e. a little more than twice as wide as long, but otherwise of the same type as in the other specimens. Ratio of eyes AME : ALE : PME : PLE = 10 : 19 : 12 : 14. Clypeus $\frac{13}{10}$ of the diameter of AME. AME separated from each other by their diameter and equally so from ALE and PME. PME separated from each other by $\frac{36}{12}$ of their long axis, from PLE by

3.½ of their long axis. Laterals separated by ⅒ of the diameter of AME. Quadrangle wider than long in ratio 52 : 30, wider behind than in front in ratio 52 : 29. The comb on the retrolateral surface of the fourth tarsi fully developed and shown in figure 8.

(d) *Young* specimen from Dead Run Swamp.

Total with cheliceræ 3.230 mm. *Carapace* 1.360 mm. long, 1.275 mm. wide. Thoracic groove semicircular, two-thirds from anterior edge. Bristles and hair as yet little developed and in single rows in the places where in the adult they form bands. Thus in front of AME there are only three bristles in a transverse row. The middorsal row behind the eyegroup is formed by only four bristles and does not reach thoracic groove. A pair of lateral bristles on the level of the fourth middorsal bristle represent the lateral bands of the adult. There are no other bristles on the carapace, nor is there any hair. Rastellum composed of only two strong spines on the one chelicera and three spines on the other. Promargin with four teeth, retromargin with four teeth, all far apart. Only two cuspules on the lip and these, like those on the maxillæ, are relatively longer than in the adult. On the maxillæ there are only few cuspules and they are not arranged in any definite manner, in fact there are nearly twice as many cuspules on the one maxilla as on the other. There are also a few short spines present. Third trochanters with a long flap representing the hook of the adult. Modified spines or hooks on palpi and first and second legs still wanting. Instead, definitely arranged spines of considerable length are present on all legs.

On the palp the spines are distributed as follows: Femur-prolateral 1 apical, elsewhere 0; Patella—prolateral 1, elsewhere 0. Tibia—prolateral 1–1–1, retrolateral 1–1–1, elsewhere 0. Terminal joint, prolateral 1–1–1, retrolateral 1–1–1, elsewhere 0. The palpal claw is long and has a bifid tooth at base. On the legs the spines are distributed as follows: First leg—Femur, 0; Patella 0; Tibia—dorsal 0, prolateral 0–1–0, retrolateral 1–2–1, ventral 1 in middle. Metatarsus—prolateral—1–1, retrolateral 1–2, elsewhere 0; Tarsus prolateral 1, retrolateral 1, elsewhere 0. Second leg—same as first except: Tibia retrolateral 1, Metatarsus retrolateral 1–1, Tarsus—retrolateral 1–1. Third leg, Patella has two prodorsal apical spines. Tibia has the characteristic saddle-shaped depression and two prodorsal apical spines. Metatarsus has two prodorsal apical spines. Fourth leg—Patella has several dorsal spines with a bald space between them. Tarsus has several spines near distal end on ventral surface. Claws three; upper claws slender, with a single, very small tooth. Third claw smooth. A single trichobothrium on tibiæ, two on metatarsi and several on tarsi.

Tarsi proportionately longer than in the adult. Thus third metatarsus is 0.850 mm. long, and third tarsus 1.360 mm.; fourth metatarsus 1.275 mm. and fourth tarsus 1.020 mm. Abdomen still shows clear traces of segmentation above and below, marked by differences in coloration. The eyegroup is shown in Fig. 9. Compared with the adult, the ratio of eyes is in favor of the laterals and there is a somewhat different arrangement due to closer approximation of the laterals.

General Considerations.—From a comparison of the described specimens one is led to the conclusion that *Pachylomerus carabivorus* is a rather variable species. The eyegroup is subject to considerable variation, including such as is caused by difference in age. The distribution of bristles is more or less permanent, but their number increases considerably with age. The cuspules, especially those on the palpi and on the first and second pair of legs appear mostly later in life. The comb on the fourth tarsus may be present or wanting in the adult and is not yet present in the young. The shape of the carapace is also subject to change with age, but the ratio between its length and width and the position of the thoracic groove are permanent.

2. **Myrmekiophila fluviatilis** (Hentz).

(Plate I, Figs. 10, 11, 12).

Syn. *Myrmekiophila foliata* Atkinson. Entomol. Americana, 1886, Vol. II, pp. 131–133, Pl. V, ff. 6, 7, 12 and 14. Female.
Comstock, Spider Book, 1912, p. 239, f. 222. Male.

Comstock gives only a very brief description and a figure of the male, but neither of its palp, nor of the eyegroup.

The single specimen described here has been captured by Professor W. J. Baerg, on December 16th, 1928, at Fayetteville, Arkansas.

Male.—Total length with cheliceræ 11.0 mm. *Carapace* 6.0 mm. long, 5.3 mm. wide between second and third coxæ, 3.1 mm. wide in front. It is nearly hexagonal, with anterior and posterior margins straight and the latter but a trifle shorter than the former. Thoracic groove deep, transverse, slightly procurved and almost, though not quite two-thirds from anterior edge. Thoracic portion of carapace quite flat. Head considerably elevated toward eyegroup which forms the highest region and is set in black pigment forming a transverse rectangle which is about one-third as long as the carapace is wide at anterior edge. PME irregular in outline and silvery. Arrangement and relative size of eyes is apparent from Pl. I, Fig. 10. First row procurved with medians closer to each other than to laterals and separated from each other by less than their radius. Second row recurved with PME wide apart. Edge of carapace with short, stout, black bristles.

Cheliceræ powerful, with a longitudinal band of stout, short, black bristles in front. Rastellum on a cone-shaped protuberance (Pl. I, Fig. 11) with a group of very short spines at the end, of which only four anterior ones are shown in the drawing. These spines are arranged in a single row along inner edge of basal joint of cheliceræ for some distance. Promargin with seven black teeth, alternately larger and smaller ones. Retromargin with five or six minute granules in proximal

half. Scopula on promargin only and quite light. Fang long, curved, dark reddish-brown. *Lip* immobile, fused with sternum, much wider than long, emarginate at tip. There are a few bristles, but no cuspules on the lip. *Sternum* (without lip) longer than wide in ratio 35 : 30. It is widest between second and third coxæ, gradually narrowed anteriorly to width of lip, neatly pentagonal posteriorly.

First coxæ wide apart, fourth coxæ contiguous. *Maxillæ* rectangular, not quite twice as long as wide. Upper inner angle slightly produced. There are a few cuspules at base. Scopula very light. All trochanters, but especially those of the palpi are with a distinct ventral hump toward end. Femora of the third pair of legs much stouter than the others. First metatarsus abruptly and peculiarly swollen in distal two-fifths. In the palp the tibia is much heavier than the other segments and has near its distal end a peculiar semicircular dilation on the retrolateral surface, possibly of sexual or fossorial function. Legs 4123.

	Femur	*Pat.+Tibia*	*Metatarsus*	*Tarsus*	*Total*
I.....	5.5	6.6	3.3	2.8	18.2
II.....	5.1	5.7	3.3	2.5	16.6
III.....	3.8	4.2	3.3	2.5	13.8
IV.....	5.5	6.6	4.8	2.8	19.7

Width of first patella at the knee 1.12. Tibial Index 16.
Width of fourth patella at the knee 1.12. Tibial Index 16.

The hair clothing the legs is spine-like and varying in length and stoutness and the true spines themselves are numerous and irregular in arrangement. There are some spines even on the fourth tarsi, although the other tarsi are without spines. Trichobothria in two rows on tibiæ, metatarsi and tarsi, but the rows are not regular. Upper claws not quite similar, although both pectinated in a single row. But the row is retroventral in the proclaw and proventral in the retroclaw. Third claw quite small and smooth. Abdomen ovoid, sparcely clothed with shorter and longer spine-like hairs. Spinnerets 4. Posterior pair heavy, three-jointed, separated from each other by slightly more than the diameter of the basal joint. Third joint small, almost hemispherical. Anterior pair situated between posterior spinnerets, small, separated from each other by almost their diameter. Pedipalp rather long and peculiar in appearance inasmuch as its femur is much more slender than the tibia. The embolus (Pl. I, Fig. 12) has a row of strong teeth along its edge. *Color in alcohol:* light rufous. Abdomen light grey-brown. Fang dark reddish-brown. Embolus black. Spines on legs black.

Family **Theraphosidæ.**

3. **Eurypelma marxi** Simon.

(Plate I, Fig. 13).

Male.—Total length with cheliceræ 20.0 mm. Carapace 9.4 mm. long, 8.5 mm. wide, quite flat, clothed with short, black hair through which the red color of the chitin itself is readily visible. Edge of

carapace densely fringed with long, black hair. Thoracic groove deep, transverse. Eyes small, situated on a small tubercle, entire eyegroup rather unusually small for the genus. Both eyerows equally long. Anterior row well procurved, posterior row slightly recurved. Ratio of eyes AME : ALE : PME : PLE = 6 : 8 : 6 : 8. AME separated from each other by ⅝ of their diameter, from ALE by their radius. PME oval, twice as long as wide, widely separated from each other and separated from PLE by less than half of their short axis. Laterals separated from each other by the diameter of the AME. Quadrangle wider behind than in front, wider behind than long in ratio 21 : 14. AME separated by two diameters from anterior edge of carapace. Heavy, black bristles on eyegroup.

Cheliceræ with heavy black hair above, with fine, long, recumbent hair on outside, and with still finer, short, recumbent hair on inside. Promargin with 9 strong, black teeth. Retromargin smooth. A red scopula on retromargin. *Lip* wider than long, with numerous spinules at tip, with long, black hair. *Maxillæ* with numerous spinules at inner angle near base. Inner apical angle rather long. Scopula salmon-colored. Behind lip two red areas corresponding to sigilla. *Sternum* slightly longer than wide, egg-shaped, narrower in front than behind, covered with long black hair. Four submarginal sigilla.

Inner surface of coxæ without the fine, short spines characteristic for the genus Dugesiella. All tarsi scopulate to base. First and second metatarsi also scopulate to base, third metatarsi in anterior half, fourth metatarsi only in distal third. All scopulæ entire. Legs 4123. First leg 30 mm. second—27 mm., third—25 mm., fourth—32.3 mm. Tibia of first leg with two hooks: outer hook much larger and curved inward, inner hook small, with a spine at base almost as long as the tooth itself.

Spines. First leg—One apical midventral on patella; tibia—dorsal 0, prolateral 1–1, retrolateral 1–1–1, midventral 1–1–1. Metatarsus two apical ventral spines. Elsewhere 0. *Second leg*—Tibia—dorsal 0. prolateral 1–1, retrolateral 1, ventral 2–4 (the four apical). Metatarsus—1–3 ventral. Elsewhere 0. *Third leg*—Several spines without definite arrangement on the ventral surface of the tibia and metatarsus. *Fourth leg*—Numerous spines without definite arrangement on the ventral surface of the tibia and metatarsus and a verticellum at end of metatarsus. Heavy dorsal bristles at base of all femora, but especially on the first pair. Legs very hairy. Dorsal spines wanting. Claws concealed by the claw-tufts. Tibia of pedipalp much stouter at base than at end (Pl. I, Fig. 13), with two spines on the prolateral surface and a heavy ventral brush of long black hair. Bulb with long sharp point.

Organs of stridulation completely wanting.

Color in alcohol. Carapace red with black margin. Cheliceræ dark red-brown. Abdomen black. Legs black with bald red longitudinal stripes on femora. Below, reddish brown with legs black beyond ends of femora. Maxillæ and lip yellow.

One male captured by Miss Brenda Putnam in Colorado.

4. **Cyrtopholis bartholomei** (Latreille).

(Plate I, Figs. 14, 15, 16).

Syn. *Mygale incana* C. Koch, 1842.
Crypsidromus gypsator Becker, 1879.
Cyrtopholis antillana Thorell, 1894.
Cyrtopholis venatorius Pocock, 1903, Simon, 1903.
Cyrtopholis acutispina Strand, 1906.
Cyrtopholis pelus Chamberlin, 1917.
Cyrtopholis bartholomei (Latreille) Strand, 1906, Petrunkevitch, 1926.

This is the common Tarantula found in Saint Thomas, West Indies, and described under different names as the above list of synonyms shows. No other Tarantula occurs on the island. To my detailed description of the female, given in my paper on the spiders of the Virgin Islands, I now may add the description of a male captured by Arthur Lindborg on April 11, 1928, in front of the Grand Hotel in Saint Thomas.

Male.—Total length with cheliceræ 34.0 mm. *Carapace* 16.0 mm. long, 14.0 mm. wide between second and third coxæ, 9.0 mm. wide in front, flat, with squarely truncated anterior margin. Thoracic groove in the shape of a deep, transverse depression situated two-thirds from anterior edge. Eyetubercle transversely ellipsoidal, marginal. First row of eyes procurved, second row recurved and as long as first. (Pl. I, Fig. 14). AME alone round. Several bristles on eyetubercle. Surface of carapace clothed with recumbent, short, woolly, brown hair. Anterior edge fringed with long, buff hair. Lateral margins fringed with long, fine, light-brown hair and stout, dark-brown bristles.

Cheliceræ powerful, clothed with dark brown hair and bristles which are lighter toward end. Promargin with 13 teeth of which the proximal third and fifth are quite small. Retromargin smooth. A heavy scopula on both margins. Retrolateral surface of cheliceræ smooth, without modified hair. Fang long and slender. *Maxillæ* with distinctly produced inner upper angle. They are clothed with long bristles, and have numerous cuspules in basal third. Scopula well developed. *Lip* wider than long, with semicircular base and almost squarely truncated end. Numerous cuspules in distal quarter. Anterior edge of lip fringed with bristles. Surface of lip clothed with bristles of uneven length. *Sternum* flat, longer than wide, densely clothed with short, greyish-brown hair and long, stout, dark brown bristles. Posterior sigilla elongated, much nearer to lateral margins than to each other, separated from the margins by their own length.

Coxæ clothed in the same manner as sternum. First coxæ separated by more than the width of the lip, fourth coxæ contiguous. Retrolateral surface of the trochanter of the pedipalp and the prolateral surface of the trochanter of the first leg with a heavy brush of modified bristles, forming a *lyra*. Tibia of first leg with two apical, ventral hooks at end (Pl. I, Fig. 15) which are of the same type as in *Cyrtopholis portoricæ*. The larger hook is midventral, curved, and bears two

blunt spines, one of which is almost at the end, the other somewhat behind the first. The smaller hook is proventral in position and has a single blunt spine closely applied to it. The spines on both hooks may be seen only when the hair covering the hooks has been removed. All tarsi scopulate to base, but only the scopula of the fourth tarsi narrowly bisected by a row of a few short bristles, the other scopulæ being entire. First and second metatarsi scopulate to base, third metatarsus in distal half, fourth only at end and at that quite lightly. Legs clothed with short, recumbent, dark hair, with very long, stout hair which is almost white toward end, and with short, almost white hair which forms a fringe at the end of each joint and also the longitudinal lines as follows: a fine prolateral line on the first and second femora, two dorsal lines on all patellæ and tibiæ, and a middorsal line in the proximal third of all metatarsi. The lines of the first and second patellæ are fairly parallel, but on the third and fourth patellæ the pro-dorsal line passes in middle to the retro-dorsal side and takes the place of the retro-dorsal line which extends only from proximal end to middle of patella. Patella of pedipalp also with two parallel light dorsal lines. Trichobothria long and numerous, in two rows on all tibiæ and metatarsi and in four rows on all tarsi. Claw-tufts heavy, concealing the claws entirely. Legs 4123.

	Femur	*Patella*	*Tibia*	*Metatarsus*	*Tarsus*	*Total*
I	14.5	7.8	11.0	11.0	6.5	50.8
II	13.8	7.0	9.2	11.0	6.5	47.5
III	11.5	6.5	8.0	11.0	6.5	43.5
IV	14.5	6.5	11.0	15.5	7.5	55.0

Width of first patella at the knee 2.552 mm. Tibial index 13.
Width of fourth patella at the knee 2.494 mm. Tibial index 14.

Spines.—First leg. Femur prolateral 1 at end, elsewhere 0. Patella 0. Tibia dorsal 0, prolateral 0–1–1, retrolateral 0, ventral 2–1r–1r (and the two apical hooks mentioned above). Metatarsus ventral 1 apical, elsewhere 0. Second leg same as first, except: Tibia ventral 1r–1r–2 and 2 spines in place of the two ventral hooks of the first tibia. Metatarsus prolateral 1–1, ventral 1–3, first spine at base, the other three apical, elsewhere 0. Third leg. Femur retrolateral 1 at end, elsewhere 0. Patella prolateral 1, elsewhere 0. Tibia dorsal 0, prolateral 1–1–1, retrolateral 0–1–1, ventral 1p–2–3. Metatarsus dorsal 0, prolateral 1–1–1–2, retrolateral 1–1–1, ventral 1p–1r–3. (There is therefore an apical verticellum formed by 6 spines). Fourth leg same as third, except: Patella 0. Tibia prolateral 0–1–0, retrolateral 1–1–1, ventral 0–2–3. Metatarsus very spinose and the spines irregularly arranged. There are apparently prolateral 0–1–1, retrolateral 0–1–1 and ventral 1r–2–1r–2–1r–2–4 spines. Palp. Tibia prolateral 1–1, retrolateral 0–1, ventral 1 in middle. Elsehwere 0. Copulatory apparatus shown in Pl. I, Fig. 16.

Color in alcohol very dark brown with almost white lines on legs and fringes at end of joints. Maxillæ and lip distinctly redder.

Sub-Order **Arachnomorphæ.**

Family **Linyphiidae**

Microneta aeronautica sp. nov.

(Figures 17 to 20).

Four males of this species have been captured by Professor E. O. Essig on floating gossamer threads on November 9, 1928, on high Antioch Bridge at Antioch, California.

Type. Male.—Total length, 2.20 mm. *Carapace*, 1.02 mm. long; 0.80 mm. wide between second and third coxæ, 0.54 mm. wide in the region of the posterior row of eyes, which is 0.42 mm. long. Thoracic groove longitudinal. Head somewhat elevated and lateral eyes on a tubercle (Pl. I, Fig. 18). First row of eyes recurved, second row very slightly procurved, almost straight. AME distinctly, though not much smaller than ALE and closer to each other than to laterals. ALE of the same size as the eyes of the second row, which are equidistant. Laterals contiguous. Only AME diurnal. All eyes set in black. Quadrangle wider behind than in front in ratio 8.5 : 7, and as wide as long. Clypeus concave below AME, slightly convex toward edge, equal to ⅞.5 of the length of the quadrangle.

Cheliceræ parallel as far as the beginning of the margins. From here on they diverge and the margins are strongly oblique. When viewed from the side the cheliceræ show a sudden constriction near end, and are now less than half as stout as in middle. Outer surface (dorsal) of cheliceræ with well developed stridulatory ridges (Pl. I, Fig. 18). Promargin smooth, retromargin with 4 small teeth. Scopula wanting on both margins. Fang slender, normally curved. *Maxillæ* distinctly inclined over lip, slightly wider in front than at base. *Lip* twice as wide as long, strongly rebordered. *Sternum* almost triangular, longer than wide in ratio 24 : 21. Its anterior edge is nearly three times as wide as the lip, so that first coxæ are almost as far apart as second coxæ. Posteriorly the sternum is produced between the hind coxæ which are separated by almost their width. Legs 1423.

	Femur	*Pat.+Tibia*	*Metatarsus*	*Tarsus*	*Total*
I	1.24	1.52	1.24	0.76	4.76
II	1.16	1.42	1.04	0.64	4.26
III	0.88	0.96	0.76	0.50	3.10
IV	1.20	1.36	1.12	0.60	4.28

Width of first patella at the knee 0.119 mm. Tibial Index 7.
Width of fourth patella at the knee 0.118 mm. Tibial Index 8.

Spines on all legs arranged in the same manner, as follows: Patella dorsal 0–1. Tibia dorsal 1–1, retrolateral 0–1. No spines elsewhere. No trichobothrium on fourth metatarsus. First tibia alone (without patella) longer than first metatarsus. *Palp* with short tibia at the end of which (Pl. I, Fig. 19) is a dorsal short process directed forward.

Cymbium large. Paracymbium sickle-shaped. Embolus (Pl. I, Fig. 20) spiral, long and fine. *Color* in alcohol: Carapace yellow with dark grey marginal band and dark grey median spot in front of thoracic groove. Legs yellow. Sternum yellow with dark grey marginal band. Abdomen light yellow with black pattern above (Pl. I, Fig. 17), yellow mottled with black below.

REMARKS ON THE GENUS CASEOLA EMERTON.

Emerton established his genus *Caseola* for two species, *herbicola* and *alticeps*, the former being the type of the genus. But *Caseola herbicola* has been found to be synonymous with *Maso frontatus* (Banks) and the genus *Caseola* becomes therefore a synonym of *Maso*. Through the courtesy of Mr. Emerton I was enabled to re-examine the types of both *herbicola* and *alticeps* for the purpose of determining the distribution of trichobothria and relative proportion of the segments of the first and fourth leg.

Caseola herbicola—Type, female: First leg, ratio of Tibia : Metatarsus : Tarsus = 14 : 11 : 5. Fourth leg 14 : 14 : 6.5. First and second tibia with two rows of ventral spines. Trichobothria: First leg, Tibia 1–1–1, Metatarsus 0. Fourth leg, Tibia 1–1–2–1, the first two very small. Metatarsus 1 long trichobothrium beyond middle.

Caseola alticeps—Type, female. Ratio of Tibia: Metatarsus: Tarsus, in First leg = 12 : 10 : 7, in fourth leg = 14 : 12 : 7. No true spines on legs except one ventral spine on each femur near distal end. Trichobothria: First leg, Tibia 1–2–1–1, Metatarsus 1 beyond middle. Fourth leg same as first. Carapace and sternum smooth, not reticulated. *Caseola alticeps* is evidently generically distinct from *Caseola herbicola* and may be provisionally placed in the genus Araeoncus until the discovery of the male will make its generic affiliation clear.

Family **Thomisidæ.**

Philodromus setosus sp. nov.

(Plate I, Fig. 21).

Total length 4.675 mm. Carapace 2.21 mm. long, 2.38 mm. wide. Both rows of eyes recurved, but first row much shorter than second and much stronger recurved. Eyes of first row equal in size. AME twice as far from each other as from ALE. Distance between AME is equal to ⅓ of their diameter, that between AME and ALE to ⅔ of the diameter of AME. Eyes of second row equidistant. PME smaller than the eyes of the first row, PLE larger than the eyes of the first row. Quadrangle slightly wider than long in ratio 12 : 11, wider behind than in front. Clypeus narrower than length of quadrangle in ratio 7 : 11. Legs 2413.

	Femur	*Pat.+Tibia*	*Metatarsus*	*Tarsus*	*Total*
I	3.230	4.080	2.465	1.530	11.305
II	3.825	4.675	2.975	1.700	13.175
III	3.230	3.825	2.380	1.360	10.795
IV	3.570	4.165	2.890	1.445	12.070

A heavy scopula on all tarsi and metatarsi, except the fourth which are scopulate only at end. Spines: First leg, Femur dorsal 1–1–1, prolateral 1–1–1, retrolateral 1–1–1, ventral 0. Patella prolateral 1, elsewhere 0. Tibia 0–0–1, prolateral 1–1–1, retrolateral 1–1–1, ventral 2–2–2. Metatarsus dorsal 0, prolateral 1–1, retrolateral 0–1, ventral 2–2. Arrangement of spines on other legs the same, except on the fourth femora where we find dorsal 1–1–1, prolateral 0–1–1, retrolateral 0–1–1, and ventral 0 spines. Color in alcohol, above and below, buff with scattered brown spots. Abdomen with two narrow white bands converging to a point posteriorly. Palp as shown in Pl. I, Fig. 21. Tibial apophysis straight, Embolus short, curved. Seminal receptacle S-shaped.

One male captured on board S. S. Aconcagua sailing from Valparaiso.

EXPLANATION OF PLATE I.

Figs. 1 to 9. *Pachylomerus carabivorus* Atkinson. (a) Female from Georgia. 1, Carapace; 2, Eyegroup; 3, Chelicera showing rastellum, margins and fang; 4, Armature of retrolateral surface of second tibia; 5, Upper and third claw of left fourth leg; 6, Claw of pedipalp. (b) Female from Virginia. 7, Eyegroup. (c) Female from unknown locality. 8, Retrolateral view of fourth left tarsus showing comb and club-shaped hairs. (d) Young from Virginia. 9, Eyegroup.

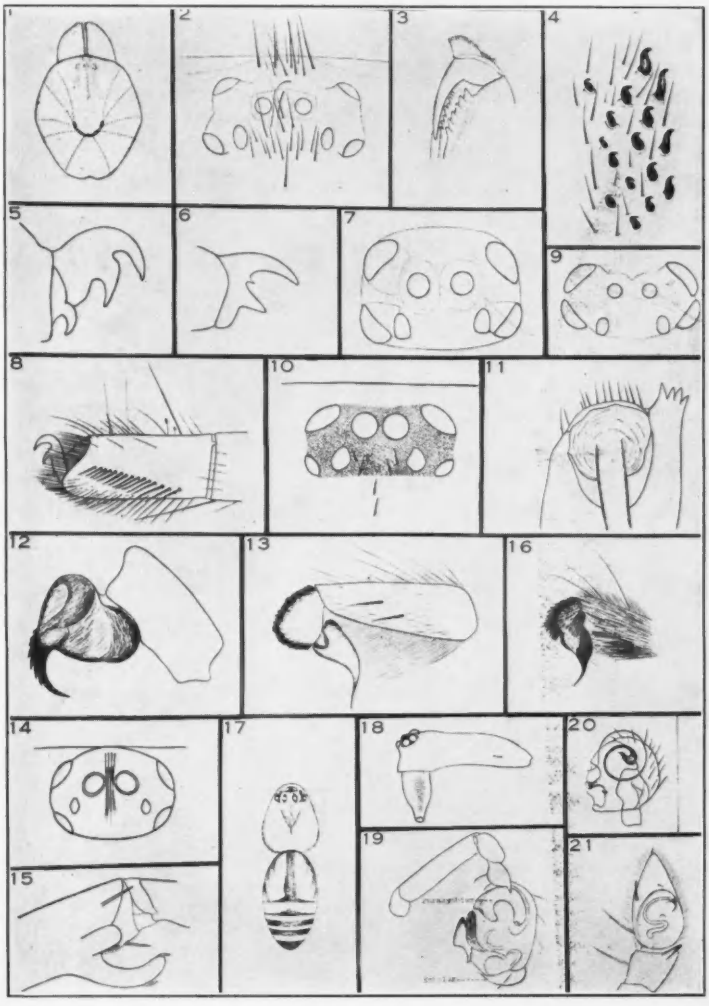
Figs. 10 to 12. *Myrmekiophila fluviatilis* (Hentz). Male. 10, Eyegroup; 11, Right chelicera viewed from below, showing rastellum on a coneshaped protuberance and base of fang; 12, Left copulatory apparatus in retrolateral view.

Fig. 13. *Eurypelma marxi* Simon. Pedipalp of male.

Figs. 14 to 16. *Cyrtopholis bartholomei* (Latreille). Male from Saint Thomas. 14, Eyegroup; 15, Prolateral view of the distal end of the first left tibia, showing the two ventral hooks with their spines; 16, Copulatory apparatus of left pedipalp in retrolateral view.

Figs. 17 to 20. *Microneta aeronautica* sp. nov. Male. 17, Dorsal view, showing pattern; 18, Lateral view of carapace, showing lateral eyetubercle and stridulatory ridge; 19, Right pedipalp in retrolateral view; 20, Same pedipalp viewed from in front, showing spiral embolus.

Fig. 21. *Philodromus setosus* sp. nov. Male. Ventral view of pedipalp.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HEIGHT AND SILKING AS FACTORS INFLUENCING EUROPEAN CORN BORER POPULATION

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The Ohio Agricultural Experiment Station.

One of the factors of the environment that "causes" fluctuations in population of the European corn borer is the stage of development of the corn during the period of moth flight and larval feeding. For several years the experimental plots at Bono, Ohio, have shown a higher population on early varieties of a given planting date than on late ones, while succeeding planting dates have shown a significant reduction in the borer population of all varieties.

TABLE 1.

Showing Mean Population for Six Varieties Planted on Five Dates, Bono, 1927.

Planting Date	Variety					
	Mean Population in Triplicate Plots					
	Wisconsin	Golden Glow	Medina Pride	Clarage	Leaming	Burr-Leaming
May 10	1102	885	859	910	686	509
May 20	740	606	579	533	504	421
May 30	419	217	225	228	108	91
June 5	168	106	129	95	77	60
June 10	36	25	41	29	14	16

The data in Table 1 show the population of six varieties planted on five different dates in 1927. The varieties are arranged in order of their length of growing season, Wisconsin No. 25 being the earliest. It will be noted that the early maturing varieties have the highest populations.

The significane of this record is indicated in Table 2, where the population of each variety is compared with every other variety. The magnitude of the difference in population between the earliest and latest variety is tremendous. On the other hand, there is no appreciable difference between some of the intermediate varieties such as Golden Glow, Medina Pride,

TABLE 2.

SHOWING SIGNIFICANCE OF DIFFERENCES IN POPULATION IN SIX VARIETIES PLANTED AT BONO, 1927.

Varieties			Odds that this Difference in Population is not Due to Chance
Wisconsin	vs.	Golden Glow	64.79 to 1
		Medina Pride	64.79 to 1
		Clarage	64.79 to 1
		Leaming	19,230.00 to 1
		Burr-Leaming	1,470,588,234.00 to 1
Golden Glow	vs.	Medina Pride	1 to 1
		Clarage	1 to 1
		Leaming	37.46 to 1
		Burr-Leaming	19,230 to 1
Medina Pride	vs.	Clarage	1 to 1
		Leaming	26.40 to 1
		Burr-Leaming	19,230 to 1
Clarage	vs.	Leaming	22.26 to 1
		Burr-Leaming	1,350.35 to 1
Leaming	vs.	Burr-Leaming	13.58 to 1

and Clarage. Relative to these three varieties, it is of importance to note that, as measured by mean silking date, there were but slight variations in their stage of maturity during the period of moth flight and larval establishment.

The coefficient of correlation between date of planting and population is -.83, the odds being 740 to 1 that the correlation

TABLE 3.

SHOWING SIGNIFICANCE OF DIFFERENCES IN POPULATION ACCORDING TO PLANTING DATES.

Planting Dates			Odds that the Difference in Population is not Due to Chance
May 10	vs.	May 20	31.36 to 1
		May 30	Over 1,470,588,234 to 1
		June 6	" "
		June 10	" "
May 20	vs.	May 30	Over 1,470,588,234 to 1
		June 5	" "
		June 10	" "
May 30	vs.	June 5	1,470,588,234 to 1
		" 10	Over 1,470,588,234 to 1
June 5	vs.	June 10	Over 1,470,588,234 to 1

is significant. Reference to Table 1 will show that the variation in the population of the various planting dates is greater than for the varieties. The magnitude of the differences in populations when one planting date is compared with another is shown in Table 3.

Corn development, however, is the resultant of numerous factors, some of which are known and some unknown. Two of the factors which are known to have a significant influence on populations are height and date of silking. It is important

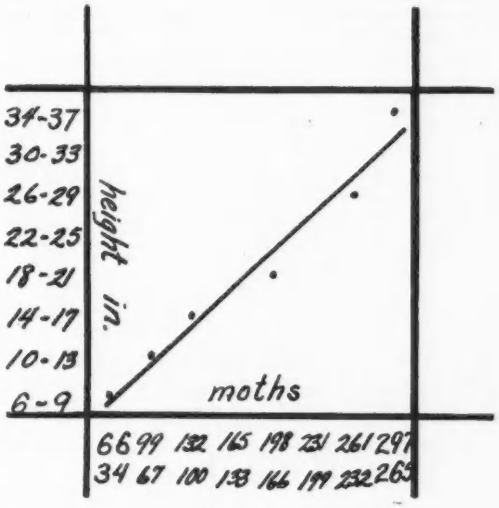

FIGURE 1.

to bear in mind that these two factors may work either together or independently. In the event they work together, as in the case of early and late planting dates, wide fluctuations in populations would occur, for under such conditions oviposition and establishment would be maximum in the former instance and minimum in the latter. In the discussion which follows it will be shown that corn borer population is fundamentally a result of either the number of eggs deposited, or the rate of larval establishment, or both and that the height and silking date of the corn are closely correlated with oviposition and establishment.

Factors Influencing Oviposition.

Height and Egg Deposition.

Moth flight for 1927 over the variety and date series of plantings indicated a close relationship between the height of the corn in the various series of plantings and the number of

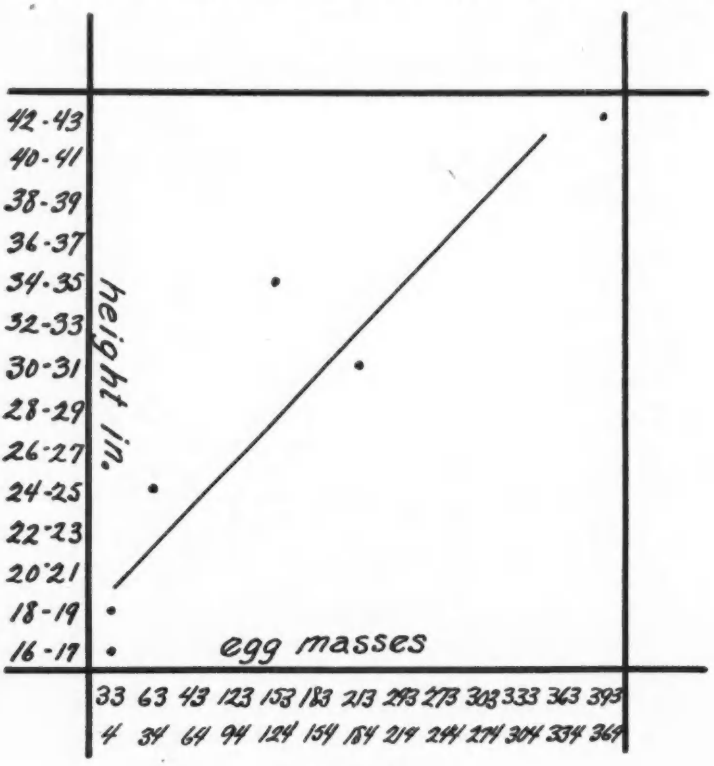

Figure 2.

moths seen flying above the respective series. From June 27 to July 12 a total of 967 moths were observed. The correlation between the number in flight and the corresponding height of these same plantings is .98 (Figure 1). The odds calculated from the formula $t = \frac{r}{\sqrt{1-r2}} \times \sqrt{n'-2}$ as given by Fisher (1)

are 4991 to 1 that there is a significant correlation. For each inch reduction in height in these plantings there was a reduction of 8.8 moths as figured from the regression equation of moths on height using this correlation coefficient.

The above record, of course, does not throw light upon oviposition except in as far as it may be inferred that the

TABLE 4.

SHOWING WEEKLY HEIGHT RECORD AND OVIPOSITION IN FIELD PLOTS.

1927.

Variety	Average Height of Plants During Oviposition Season, Inches	No. Eggs Per Plant
Burr-Leaming (Normal)	51	46
Wisconsin (Normal)	49	40
Wisconsin (Sub-normal)	43	26
Burr-Leaming (Sub-normal)	33	8

1928.

Variety	Average Height of Plants, Inches						
	Stalks examined	July 3	July 10	July 17	July 24	Season Average	No. Eggs Per Plant
Burr-Leaming (Normal)	99	32	48	61	81	56	27
Clarage (Normal)	97	30	46	60	80	54	22
Wisconsin (Normal)	99	28	42	54	71	49	16
Clarage (Sub-normal)	97	25	38	49	69	45	14
Wisconsin (Sub-normal)	100	19	31	41	57	37	8
Burr-Leaming (Sub-normal)	99	16	27	39	55	34	5

moths would deposit eggs in the various local areas of the field in which they were observed. The writers have presented data (2) showing the actual egg deposition on two varieties of corn, Clarage and Golden Bantam, when planted on three different dates. When the average height of these varieties is plotted against egg masses a correlation coefficient of .97 is obtained, the odds being 3558 to 1 that this result is significant. (Figure 2). For each inch reduction in height of these plots there was a reduction of 14.5 in the number of egg masses deposited as figured from the regression equation of egg masses on height using this correlation coefficient.

In a former publication, (2) the writers presented data showing the relation between oviposition and plant height for two varieties of field corn, each occurring under two different growth conditions. In Table 4 it is shown that there was a marked decrease in egg deposition as the average height of plants decreased, irrespective of varieties. The correlation coefficient in this instance is .99, the odds being over 600 to 1 (Figure 3) that plant height and oviposition are correlated.

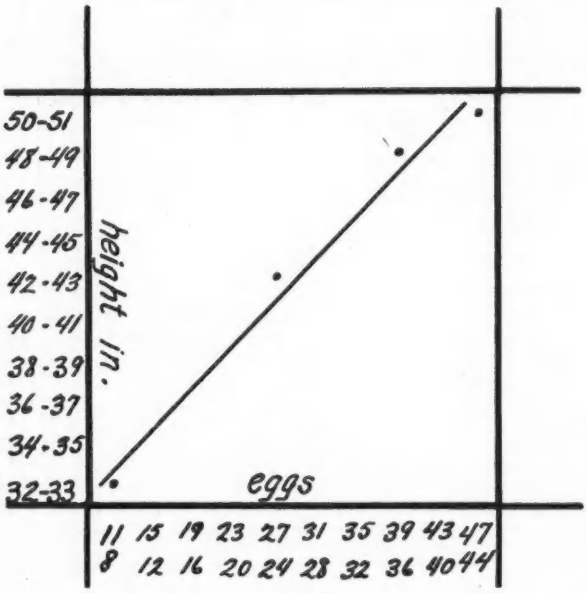

FIGURE 3.

In this case for each inch reduction in height there was a decrease of 1.9 in the number of eggs deposited.

The data for 1928 in Table 4, likewise show high correlation between egg deposition and height of plant, the correlation coefficient in this instance being .97 with odds of 7142 to 1 that this correlation is significant. (Figure 4). For each inch decrease in height there was a reduction of .9 in the number of eggs per plant as calculated from the regression equation of eggs on height using this correlation coefficient. In each of

the two years it was found that the greater the average height of corn in the plot the more eggs were deposited. The records seem especially significant in that the one variety that had both maximum and minimum average heights also had maximum and minimum average egg deposition. In like manner all other plots were in the same relative position in the attractiveness rating as in the height rating.

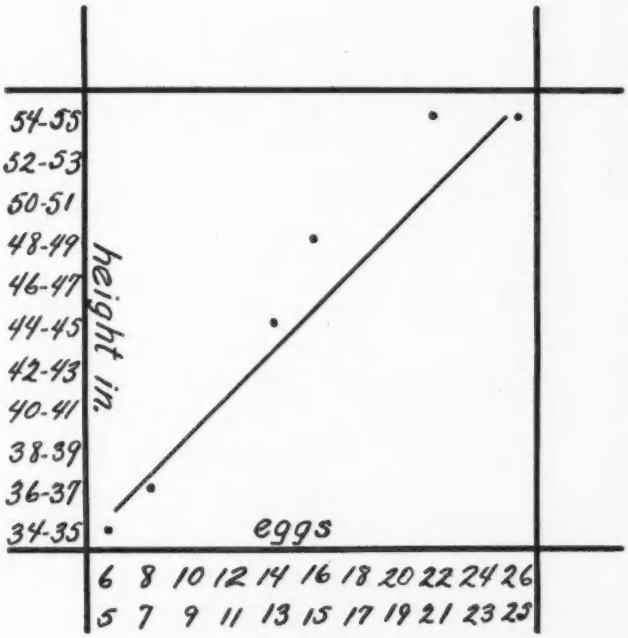

FIGURE 4.

It may be seen that the records for the two years, 1927 and 1928, are closely analagous, there being not only a steady decrease in oviposition as the height decreases, for each year, but also a slight variation in the percent decrease in egg deposition per inch decrease in height for the two years. In other words, not only is the attractiveness of different heights consistently and uniformly variable for each year but also the ratio of variability is practically equivalent for the two years.

It is now of interest to inquire into the relationship between number of eggs per plant and the height of individual plants within a single plot as contrasted with the high correlation

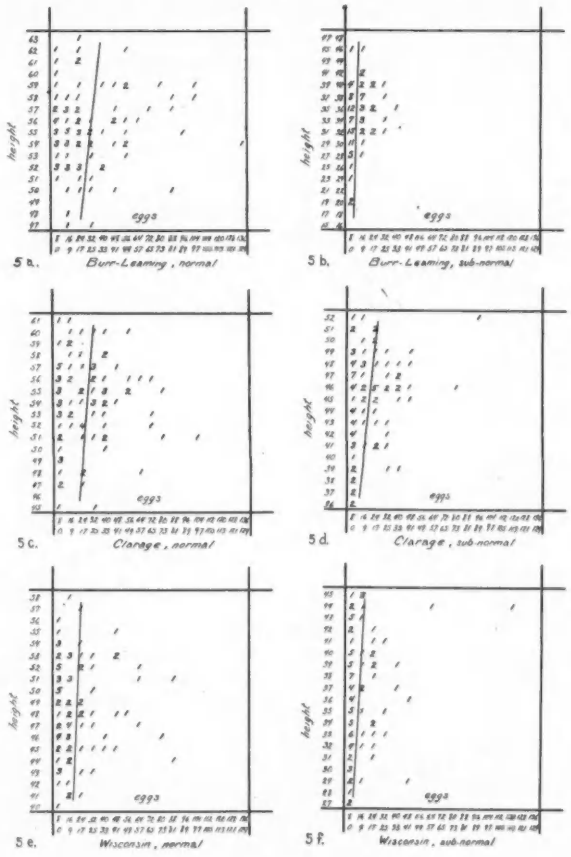

FIGURE 5.

found between number of eggs by plots and the average height of plots. Individual records on development and oviposition were kept on all plants within the different plots studied in 1928. These records throw light on whether or not the moths oviposit on the individual plants of the plot at random or

whether in this instance they also respond with respect to plant height. Reference to Figure 5, a to f, and Table 8 will indicate at once that there is only a slight correlation between oviposition and the height of individual plants within a plot. The straight lines, Figure 5, a to f, graphically illustrate the degree of correlation. Although there is a slightly greater number of eggs deposited on the larger plants, it would appear that there is no important tendency for the moth to select them as compared to the tendency shown in the data for the plots as units, since random oviposition would result in a greater number of eggs on the larger plants.

TABLE 5.

SHOWING COEFFICIENTS OF CORRELATION BETWEEN HEIGHT OF INDIVIDUAL PLANTS AND NUMBER OF EGGS.

Variety	Condition	No. of Plants	CORRELATION	
			Value	P. E.
Burr-Leaming	Normal	99	.1075	.066
Burr-Leaming	Sub-normal	100	.2652	.062
Clarage	Normal	97	.1307	.066
Clarage	Sub-normal	99	.2307	.064
Wisconsin	Normal	96	—.0375	.069
Wisconsin	Sub-normal	99	.1211	.066

Silking and Egg Deposition.

Having shown the correlation between height of plant and egg deposition it is now in order to discuss the relationship between silking and oviposition. Data secured on the Bono varietal and date of planting plots in 1927, as previously described, in which six varieties were planted in triplicate on six different dates, showed a correlation of -.91 between silking and egg deposition, the odds being 615 to 1 that the correlation is significant. The correlation between moth flight and silking on these same plots is -.97, the odds being 4055 to 1 that the result is significant. This high correlation might lead to the conclusion that date of silking as such, greatly influences the moths and consequently the number of eggs deposited. However, in this instance silking includes more than stage of development as such. Where the six varieties are made the equivalent of one variety on the successive dates of planting a high correlation between silking and eggs can be expected for the correlation between silking and height is high.

Just what it is that attracts the moths to the corn plants is not known. It is not even definitely known by what sense the insects respond to the stimulating attractant. For this reason it is impossible to say that height of plant is the determining agent. It is perfectly fair to state, however, that in so far as the foregoing records are concerned, attractiveness correlates directly with height of plant in all cases. Therefore, the attractive agent, if not height itself, certainly must be directly proportional to height during the oviposition period.

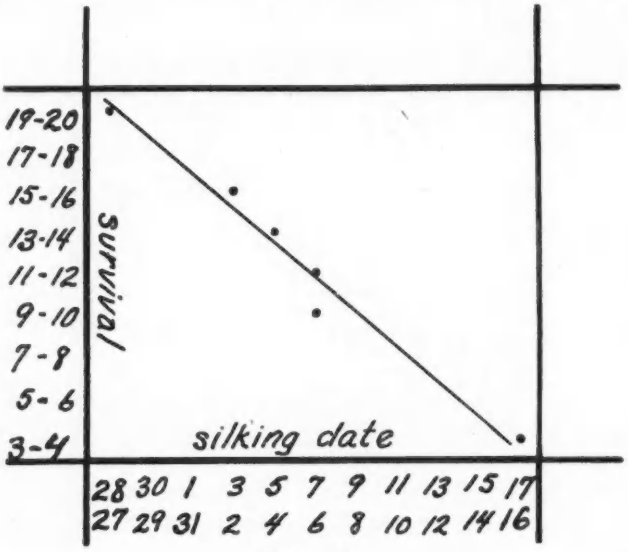

FIGURE 6.

FACTORS INFLUENCING ESTABLISHMENT.

Early vs. Late Planting.

The relationship of the actual number of eggs and the survival rate of larvæ as factors influencing final population will now be considered. It is a demonstrated fact that moths deposit more eggs on early than on late corn and on high than low growing corn (2). Moreover, it is accepted that early corn generally carries a higher borer population than late corn. Is this difference in population due to a difference in the number

of eggs only or does earliness or lateness of corn have an influence on the chances of survival?

Results of certain studies in 1925 indicated that differences in populations were not wholly due to variations in number of eggs. As a consequence of this supposition Mr. E. G. Kelsheimer in 1926 artificially infested each of 18 stalks of corn, 9 planted on May 10 and 9 planted on June 10. This corn was all of the same variety planted in adjoining plots. The number of eggs placed on the corn and the percent of larval recoveries are given in Table 6.

TABLE 6.

SHOWING LARVAL SURVIVAL ON CORN PLANTED MAY 10 AND JUNE 10, 1926.

Time	PLANTED MAY 10		PLANTED JUNE 10	
	Eggs Deposited No.	Larvæ Recovered %	Eggs Deposited No.	Larvæ Recovered %
July 10	194	13.9	194	4.1
12	194	5.1	194	3.1
14	176	6.8	176	.0
14	200	12.0	200	5.5
16	150	12.6	150	12.0
19	190	7.9	190	5.3
19	196	8.7	182	8.8
21	247	6.1	228	7.9
22	168	18.4	168	4.8
Average		10.16		5.72
Difference				4.44

According to the formula $t = \frac{\bar{x} - \bar{x}^1}{s} \sqrt{\frac{(n_1+1)\ (n_2+1)}{n^1+n^2+2}}$ by Fisher (1) the odds are 68.0 to 1 that the foregoing difference, 4.4 percent, is significant.

In 1928 a series of plots consisting of different varieties of dent, sweet, and flint corn were studied for survival rates under two widely different dates of planting. As far as was known all environmental conditions except the condition of growth resulting from the differences in planting date were kept constant for each variety. The varieties, however, were grown in different localities, hence cannot be compared.

Each plot, Table 7, consisted of 36 plants arranged in a rectangle. By means of moths confined in cages, oviposition

was forced on all of the hills of each plot, corresponding parts of each plot being subjected to oviposition at the same time in order to obtain comparable treatments. The natural deposition of the eggs on the plants by the moths themselves is contrasted here to the artificial deposition described in the experiment above. It will be seen that the final results are practically the same.

TABLE 7.

SHOWING SURVIVAL ON EARLY AND LATE PLANTINGS, OAK HARBOR, 1928.

Variety	Plants in plot	Eggs per Plot		Larvæ Recovered per Plot		Percent Survival		Percent Reduction in Survival
		May 10	June 10	May 10	June 10	May 10	June 10	
Golden Bantam.....	36	8007	7322	1289	636	16.10	8.69	46.02
S. Evergreen.....	36	8093	4052	753	193	9.32	4.76	48.93
Leaming.....	36	11915	8980	1578	803	13.24	8.94	32.48
Long. Flint.....	36	8108	8697	909	285	11.21	3.27	70.83
Average.....	.....	.....	.....	.....	.....	.....	.....	49.565

The data in Table 7 show clearly that there was a difference in survival on the May 10 and June 10 corn, the average reduction being 50.43 percent. According to the formula $t = \frac{\bar{x}\sqrt{n^1}}{s}$ the odds were 129 to 1 that this difference in survival is significant.

Early vs. Late Developing.

(Normal Against Subnormal Corn).

It has been shown elsewhere (2) that there was a considerable difference in the larval survival on normally and subnormally growing Wisconsin and Burr-Leaming varieties in 1927. On the subnormal Wisconsin 44.25 percent as many borers survived from a given number of eggs as on the normal, while on the subnormal Burr-Leaming the survival was 53.67 percent as great as on the normal plot. The average survival on the subnormal plots was 48.96 percent of the normal. These are significant differences. While no record was kept on the date of silking of the different plots it is known that the vigorous series silked several days earlier than the non-vigorous.

In 1928 similar records were taken except that two development rates of Clarage were included and silking date records of all plants were taken on each plot. It may be noted that in case of every variety listed in Table 8 there was a heavier egg deposition in the vigorous than in the subnormal series. Despite the possible influence of competition there was a higher percent survival on the vigorous than on the subnormal. The subnormal plots, as an average, silked 6.7 days later than the normal and had 36.70 percent lower larval survival, or a reduction of 5.5 percent in larval survival for each day's delay in

TABLE 8.

SHOWING COMPARATIVE SURVIVAL ON CORN WITH TWO DEVELOPMENT RATES, 1928.

	Eggs per Plant	Popula- per Plant	Percent Survival	Average Silking Date	Decrease in Survival in Percent of Normal Plot	Percent Decrease in Population
Wisconsin No. 25.						
Vigorous Plot...	16.17	3.21	19.9	July 27.5	19.10	58.56
Subnormal plot..	8.28	1.33	16.1	Aug. 2.1		
Clarage.						
Vigorous plot....	22.12	3.20	14.5	Aug. 4.7	22.07	49.38
Subnormal plot..	14.28	1.62	11.3	Aug. 7.9		
Burr-Leaming.						
Vigorous plot....	26.61	2.75	10.3	Aug. 6.2	68.93	93.82
Subnormal plot..	5.24	.17	3.2	Aug. 17.6		
Average.....	.....	.....	.....	.....	36.7	

date of silking even within the variety. These data show that the average survival on the subnormal plots was 63.30 percent as great as on the normal, the odds being 65.7 to 1 that this result is significant.

Short Season Varieties vs. Long Season Varieties.

Evidence presented in Tables 6 and 7 warrant the deduction that larval survival was lower on late than on early corn and, therefore, contributed to reduction in the population of the late corn. It has been pointed out previously that fundamentally the difference in development of a single variety planted on two different dates may be equivalent to the difference obtaining in two different varieties planted on the same date. It is to be expected, therefore, that survival will vary according to varieties.

It has been shown also (2) that a higher percent survival occurred on Wisconsin No. 25, an early maturing variety, than on Burr-Leaming, a late maturing variety. The comparison of varieties in 1928 gave the same result but was made increasingly significant by the addition of another variety and by the fact that complete silking date records were taken. The record for 1928 is given in Table 9. The percent survivals are arranged in order of the silking date of the varieties.

In this record (Table 9) it may be seen that in every case except one there was a regression of percent survival with

TABLE 9.

SHOWING RELATION OF PERCENT SURVIVAL WITH DATE OF SILKING, 1928.

Variety	Silking	Percent Survival	Delay in Silking Date as Compared With Earliest	Decrease in Survival as Compared With Max.	
				Actual	Percent
			Days		
Wisconsin No. 25.....N	July 27.5	19.9	0.0	0.0	.....
Wisconsin No. 25.....SN	Aug. 2.1	16.1	5.6	3.8	19.1
Clarage.....N	Aug. 4.7	14.5	8.2	5.4	27.1
Burr-Leaming.....N	Aug. 6.2	10.3	9.7	9.6	43.2
Clarage.....SN	Aug. 7.9	11.3	11.4	8.6	48.2
Burr-Leaming.....SN	Aug. 17.6	3.2	21.1	16.7	83.9
Average.....	.....	.....	11.2	.....	44.3
Average percent decrease in survival per day delay in silking.....	.....	.....	1.0	.....	4.0

earliness of silking. The coefficient of correlation is .98, the odds being 4761 to 1 that the correlation is significant. Figure 6 shows the regression of larval survival on date of silking calculated from this coefficient of correlation.

Although the correlation between survival and stage of maturity was high on whole plots, an analysis of the data with respect to the relation of silking and population of individual plants of the plots showed only a small correlation. When these correlation values (Table 10) are transformed to Z according to the method given by Fisher (1) and then retransformed, the value of the generalized correlation coefficient is found to be $-.18 \pm .03$. When this is compared with the correlation coefficient of .98 obtained when the correlation is calculated for

the whole plots it seems evident that other factors are nullifying the influence of maturity of the corn on survival. It is probable that one of these factors, possibly the major one, is the migration of larvæ from early maturing stalks to late ones within the same hill or between hills. Such migration would effect a general leveling of population.

Summary.

The question naturally arises as to why delay in maturity as indicated by silking should reduce the survival rate of corn borer larvæ. No definite answer can be given to the question at present. However, in connection with a seasonal history study made on various varieties of corn in 1927 and 1928, it was found that the greatest difference in mortality occurred at the time the larvæ were becoming established upon the corn plant or were starting to feed. Data secured in 1928 showed that by the end of the two-week period including July 16-31 there already had been a mortality of a little over 79 percent in Burr-Leaming and Clarage, while in Wisconsin it was under 70 percent. The average mortality for the season, i.e. from July 16 to September 12, was 79, 86, and 88 percent, respectively, for Wisconsin, Clarage, and Burr-Leaming.

An analysis of the location of the larvæ in the different varieties during this period shows that on July 23-25, 45 percent of the larvæ in Wisconsin, No. 25 were feeding on or amid the tassel. In Burr-Leaming there were only 8 percent amid the

TABLE 10

Showing Coefficient of Correlation Between Silking and Population of Individual Plants.

Variety	Plants		Correlation		
	Kind	No.	Value	P. E.	Z Value
Burr-Leaming	Normal	99	—.3665	.058	—.384
	Subnormal	100	—.2003	.065	—.203
Clarage	Normal	97	.0636	.067	.064
	Subnormal	99	—.2166	.065	—.220
Wisconsin	Normal	96	.0485	.068	—.049
	Subnormal	99	.1788	.065	—.181

tassel, while a correspondingly large number were amid the rolled leaves of the plant. In other respects there was not a great difference in the location of the borers in the two varieties. A week later, July 30—August 1, there were 5.6 percent in the tassel of Wisconsin to 12.4 percent in Burr-Leaming, while Wisconsin already had 28 percent within the plant stem to 5 percent in Burr-Leaming.

It would appear that as far as the evidence presented herein is concerned the resistance to the attack of the corn borer rests upon two factors, (a) resistance to oviposition and (b) resistance to survival. The later corn, or that which is smaller during moth flight, exhibits a greater resistance to oviposition than does that which is earlier and larger at the same period. Conversely, that which is larger is more attractive. Resistance to survival varies inversely with the silking date of the host, whether variety, planting date, or merely rate of development within a given variety or planting date is concerned.

The difference in place of feeding is correlated with the fact that in Wisconsin the tassels appear earlier than in Burr-Leaming and also that the tassels open up sooner in Wisconsin, thus forcing the borers inside the stem at an earlier date. Inasmuch as the mortality for the remaining larval period was practically equivalent in the two varieties it seems logical to assume that this specific difference in the development of the varieties was responsible for the difference in the survival rates. It would appear rather certain that the time of tasseling has a very definite relationship to the development of young larvæ and that the early tasseling hosts are more perfectly timed to the early larval growth and accordingly larger percentages of larvæ are able to become established upon them.

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DESCRIPTIONS OF FIVE NEW NORTH AMERICAN ANTS, WITH BIOLOGICAL NOTES.*

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Recently there have come to my attention five new ants which seem worthy of description. Among them is a new Ponerine ant and four new Myrmicine ants, all of which are native to Mississippi except the species *Pogonomyrmex californicus barnesi*, an Arizona ant. Included with these descriptions is that of the heretofore undescribed male of *Ponera opaciceps* Mayr. Where possible, comments have been made on the biology of these ants.

I wish to acknowledge here my indebtedness to Dr. W. M. Wheeler, of Harvard University, for his opinion concerning the taxonomical status of these ants.

PONERINÆ.

Euponera (Trachymesopus) gilva harnedi subsp. nov.

Worker. Length: 2.9–3.1 mm.

Head, excluding mandibles, slightly longer than broad, but not quite so broad as with typical specimens of the species. Posterior border not strongly but yet clearly emarginate, sides faintly convex, converging anteriorly, thus causing the width of the head in the region of the mouth to be narrower than the width of the head measured through the posterior angles. Eyes very small and indistinct, with only 8-10 ommatidia; placed at a distance from the mandibles equivalent to at least two and a half times their greatest diameter. Mandibles well developed, triangular, moderately convex, with 6-8 distinct teeth. Clypeus short, strongly carinate, medianly, especially near the posterior border. Frontal carinæ flattened, each forming a distinct lobe which covers most of the antennal insertion; between these and extending posteriorly is a narrow, impressed, frontal groove which reaches almost to the vertex of the head. Antennal scapes robust, lacking approximately twice their greatest diameter from reaching the posterior border of the head; funiculi gradually becoming broader distally, all segments except the first and last distinctly broader than long.

Pronotum narrower than the head, long as broad, flattened above and with broadly rounded humeri. Pro-mesonotal and meso-epinotal sutures distinct. Epinotum not so long or as wide as the pronotum and

*A contribution from the Mississippi Agricultural Experiment Station.

mesonotum together, laterally compressed at the base, but becoming wider posteriorly; in lateral profile its dorsal outline is almost straight, horizontal, and lower than the mesonotum, and passes into the declivity in a rather rounded angle. Petiole slightly broader than the posterior part of the epinotum, with broadly rounded dorsal surface, and prominent, rounded, plate-like tooth below. Gaster oval, truncate at base, widest at posterior border of second segment, apex with a well developed sting.

Mandibles smooth, shining, with a few sparse piligerous punctures which are largest near the apical borders, at the base with several indistinct striæ. Head opaque, finely and densely punctate, with a velvety effect. Thorax, petiole, gaster and legs less opaque, slightly shining, with very fine scattered punctures.

Hairs and pubescence golden yellow. Pubescence fine, dense, and closely appressed on the head, less so on the thorax, on the abdomen longer, coarser and less appressed. Hairs erect, moderately long, scattered over the body but most evident on the gaster.

Ferruginous, appendages scarcely paler, mandibles darker.

Described from numerous workers, the cotypes of which are in my collection, the collection of the Department of Entomology of the Mississippi A. & M. College and the collection of Dr. W. M. Wheeler.

The ants of this interesting subspecies were taken from beneath the bark of a moist, rotting pine log in a woodland strip at Columbus, Mississippi. The ants were very slow of movement and in some cases feigned death at the point of capture. The workers bore such a close resemblance to the workers of *Proceratium* or *Sysphincta* in size, color and movements, that I did not recognize them as something different until I reached the laboratory. It is interesting to remark here that from the same log came also a new Fulgorid belonging to the genus *Epiptera*, but which was apparently not associated with these ants nor the ants *Aphanogaster texana* var. *carolinensis* Wheeler.

In regard to the rarity of *E. gilva* (Roger), Wheeler and Gaige have written in Psyche, vol. 27, p. 69 (1920) as follows: "In 1863 Julius Roger described, among other North American Formicidæ, *Ponera gilva* and *Discothyrea testacea*, two species which the senior author has vainly sought for the past twenty years, both in the field and in numerous collections sent him for identification. 'Nordamerika' was the only locality appended to the descriptions, and as the other species of the two genera are tropical or subtropical, it was natural to infer

that Roger's types were taken somewhere in Mexico. The *Discothyrea* is still to be rediscovered, but recently the junior author succeeded in taking four workers of *gilva* in northwestern Tennessee." The authors also state, "but *gilva* must either be extremely local or its female would have turned up in some of the many collections made since 1863. It would seem to be in fact, an ancient relic on the verge of extinction."

The workers of this new subspecies differ in a number of respects from that of the typical *gilva* described by Wheeler and Gaige in the issue of Psyche mentioned above. The differences are as follows: (1) the body is somewhat smaller and less robust; (2) the head narrower, and with shorter antennal scapes; (3) the eyes smaller; (4) the sculpturing finer and more shining; (5) the pilosity less coarse, and also less abundant.

I take pleasure in naming this ant for Professor R. W. Harned, who has kindly aided me in every possible way in my studies on North American ants and especially those ants native to Mississippi.

Ponera opaciceps Mayr.

Male. (Alate)—Length: 2.4–2.6 mm.

Head, excluding the mandibles, scarcely longer than broad, with rounded posterior angles. Eyes large, oval, convex. Ocelli arranged in the form of a triangle, the distance between one of the lateral ocelli and that of the median ocellus less than the distance between the two lateral ocelli. Cheeks extremely narrow. Mandibles small, short, edentate. Clypeus strongly convex, the anterior border without a median emargination. Antennæ 12-segmented, filiform; scapes short and slender, not longer than the second funicular segment. Thorax short, robust. Mesonotum with distinct parapsidal sutures, but without Mayrian furrows. Wings pale, with faint yellowish veins. Anterior wings, each with a closed radial cell, two closed cubital cells and a closed discoidal cell. Legs moderately long and slender, the tibæ of each with a distinct spur at its distal end. Petiole viewed in lateral profile broad at the base and perceptibly narrowing dorsally; from behind, the superior border of the petiole is rounded and entire. Gaster from above subelliptical, with a distinct constriction between the first and second gastric segments, the apex with prominently protruding genital appendages.

Subopaque; body finely shagreened, the shagreening covered by a dense, much appressed yellowish pile. Hairs yellowish, rather short, sparse, found on the mandibles, clypeus, top of head, coxæ of the legs, top of the petiole and apex of the gaster.

Black; mouth parts, appendages, wing insertions, and apex of the gaster lighter, or pale yellow.

This description is based on 12 alate males which were taken by Mr. J. P. Kislanko on December 15, 1928, from a colony nesting in a partly decayed pine stump at Ocean Springs, Mississippi. The cotypes are in my collection and the collection of the Department of Entomology of the Mississippi A. & M. College.

Ponera opaciceps ranges throughout the southern states and as far south as Mexico and Brazil. The worker of this species bears a close resemblance to the worker of *Ponera coarctata* subsp. *pennsylvanica* Buckley, but can be distinguished from the latter by its shorter, more robust head and by the finer punctation of the head. *Ponera opaciceps* is a southern form, whereas *P. pennsylvanica* is more northern in its distribution.

MYRMICINÆ

Pogonomyrmex californicus barnesi subsp. nov.

This form seems to be intermediate between that of the typical *californicus* and its subspecies *maricopa*, but is perhaps nearer the latter. The worker of *barnesi*, however, resembles to some extent the worker of *maricopa* not only in size (6–7.5 mm.), but also in its subopaque appearance.

It differs from the worker of *maricopa* though in many respects, namely: (1) the node of the petiole is decidedly higher and more pointed above and with a rather abruptly sloping or steep posterior slope, and the pedical bears below a distinct antero-ventral tooth; (2) the rugæ of the head and the thorax are much more pronounced and have very distinct interrugal punctures, and the petiole and post petiole are more coarsely shagreened; (3) the head, thorax, petiole and post petiole are much less shining than in the worker of *maricopa* and therefore practically opaque; (4) the color is a darker, more ferruginous red.

I am able to distinguish this form very readily from its nearest allies, *californica* and *maricopa* in that the workers of *barnesi* are more heavily sculptured and therefore more opaque, are darker in color, and possess a petiole of a very characteristic shape as described above.

This new subspecies is described from 8 specimens, all workers, which were taken by Mr. O. L. Barnes in Maricopa county, Arizona about twenty miles northwest of Phoenix.

Cotypes are in my collection and in the collection of the Department of Entomology of the Mississippi A. & M. College.

I take pleasure in naming it for Mr. Barnes who has kindly sent me a number of Arizona ants for identification.

Leptothorax wheeleri sp. nov.

Worker.—Length: 2.2–2.9 mm.

Head, rather large, subrectangular, excluding the mandibles, slightly longer than broad, with practically straight posterior border, rounded posterior angles and feebly convex, almost straight, subparallel sides. Eyes moderately large, oval, convex, placed at a distance from the mandibles equivalent to or slightly surpassing their greatest diameter. Mandibles with 5 distinct teeth. Clypeus convex, with rounded anterior border, and a rounded posterior border extending for some

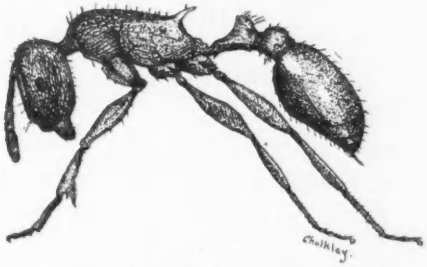

Fig. 1. Worker of *Leptothorax wheeleri.*

distance between the frontal carinæ. Frontal area obsolete. Antennæ 11-segmented; scapes fairly robust not attaining the posterior angles of the head, first segment of the funiculi almost as long as the next three taken together, the distal segment longer than the two preceding segments taken together. Thorax robust, narrower than the head, anteriorly with rounded, yet distinct humeral angles; dorsum convex, sides not laterally compressed as with *fortinodis* and related species. Epinotal spines rather robust, long and curved, slowly narrowing to their apices which are directed upward, backward, and outward. Petiole viewed in lateral profile, not strikingly larger than the postpetiole, with feebly concave anterior and faintly convex or somewhat flattened dorsal surface, below with a distinct ventral tooth. Postpetiolar node strongly convex dorsally. Gaster viewed from above oval, truncate at base, with distinct humeral angles, apex with a sting. Legs stout, with incrassated femora.

Head, thorax, petiole, postpetiole and antennæ opaque. Mandibles longitudinally striated. Clypeus coarsely, longitudinally rugulose. Head, thorax, and petiole rather coarsely rugulose-recticulate, with the interspaces finely punctate; on the head and thorax the rugulæ are

decidedly longitudinal. Postpetiole finely punctate. Gaster smooth and shining, the legs less so.

Hairs light yellowish or grayish, short and rather abundant, erect on the head, thorax, epinotal spines, petiole, postpetiole and gaster.

Color, light to dark ferruginous red; gaster except the posterior borders of the segments and legs slightly paler. Mandibular teeth black. Antennæ somewhat infuscated, especially the funiculi.

Female (dealated).—Length: 3.9–4.2 mm.

Like the worker in coloration except that the ocelli, the mesoparapteral furrows, the wing insertions, the posterior edge of the scutellum, the metanotum, and a rather broad band at the distal end of the first gastric segment and a fainter band at the tip of the second and third gastric segments are infuscated.

Sculpturing similar to that of the worker, but coarser, especially on the thorax. Epinotal spines not as proportionally large as with the worker, but shorter and blunter, the intraspinal spaces greater than the length of either epinotal spine. The petiolar node of the female is decidedly more convex dorsally and has a sharper more abrupt posterior slope than that of the worker.

Pilosity and pubescence not noticeably different from that of the worker.

Described from 5 females and numerous workers, all of which were collected at A. & M. College, Mississippi. Cotypes of the females and workers are in my collection and the collection of the Department of Entomology of the Mississippi A. & M. College. Worker cotypes only are in the collection of Dr. W. M. Wheeler.

This species is very closely allied to *fortinodis*, *schaumi*, and *bradleyi*. Like these species, the workers and female have 11-segmented antennæ. The worker differs from that of *fortinodis* and *schaumi* in several respects, the most striking of which are: (1) that it has much longer and larger epinotal spines; (2) that the thorax is not compressed laterally and dorsally as with the two species just mentioned; (3) that the sculpturing is much coarser. From the worker of *bradleyi* it differs in the shape of the thorax and petiole, and also in several other characters.

I take pleasure in naming this species for Dr. W. M. Wheeler of Harvard University, the world's foremost formicologist, and to whom I am greatly indebted for considerable aid in my work on the ants of North America.

This large and beautiful, ferruginous-red species of ant is rather common in this vicinity. It was first collected in 1921

and erroneously referred to *Leptothorax schaumi*. (See Ent. News. Vol. 35, p. 50, 1924).

One colony was found nesting in an oak tree, apparently in the hardwood where the ants could be seen entering and leaving by small holes in the wood which I believe to have been made by some small boring beetle. March 20, 1922 I found a colony nesting in a niche in a dead, but fallen cottonwood tree. In this colony were 2 dealated females, 31 workers and a number of larvæ, but no other immature forms. April 25, 1928 another colony was found nesting in a cavity beneath the bark of a well rotted pine stump. In this nest were found 3 dealated females, 40 workers, and numerous larvæ. When the nest was disturbed the workers made frantic efforts to conceal themselves by crawling in small crevices, etc. The ants have also been taken in similar habitats at Adaton, Mississippi. Nothing is known concerning their feeding habits.

Leptothorax (D.) pergandei flavus subsp. nov.

Worker.—Length: 2.6–2.8 mm.

Head subrectangular, excluding mandibles, longer than broad, posterior border straight, posterior angles rounded, sides moderately convex, subparallel in appearance. Eyes rather large, oval, convex, placed at a distance from the mandibles equivalent to their greatest diameter. Mandibles with 5 distinct teeth. Clypeus moderately convex, broadly rounded in front and extending some distance posteriorly between the frontal carinæ. Frontal area obsolete. Antennæ 12-segmented; scapes surpassing the posterior angles of the head; club 3-segmented, the distal segment longer than the two preceding segments taken together. Thorax robust, viewed in lateral profile the dorsum of the prothorax and mesothorax form a rather long, well developed arch, which terminates at the deep and broad constriction between the meso-epinotum. Epinotal spines moderately large and robust, rather blunt, directed upward and outward. Legs with incrassated femora. Petiole viewed in lateral profile with well developed, rather strongly convex node and with a distinct anteroventral tooth beneath; postpetiole considerably larger than the petiole. Viewed from behind the superior border of the petiole is straight or rounded and without an emargination, postpetiole much broader than long and easily one and a half times as broad as the petiole. Gaster oval, truncate at base, and with well developed humeral angles, apex with a sting.

Mandibles longitudinally striated. Clypeus smooth, except for a median carina on its anterior border and longitudinal rugulæ on its lateral border. Head, with the exception of the longitudinal rugulæ around the base of the antennæ and on the cheeks, prothorax, dorsum of mesothorax and epinotum, petiole, postpetiole and gaster, smooth

and shining. Neck opaque, delicately rugulose-punctate; mesoepinotal constriction, and the pleuræ of the mesothorax, metathorax and epinotum, rugulose-reticulate.

Hairs white, coarse, long and abundant, erect on all parts of the body except the appendages; almost absent from the pleuræ of the thorax.

Yellow to yellowish brown; mandibular teeth black, head, antennæ, dorsum of mesothorax, legs, and posterior border of the gastric segments infuscated. The color of the body and the amount of infuscation is highly variable with different individuals.

Female (dealated).—Length: 3.6 mm.

As a whole very similar to the worker but differing to some extent in sculpture, color, shape and size of epinotal spines, and several other characters. The sculpturing is similar to that of the worker except that it is coarser; the rugulose-reticulate sculpturing is missing from the mesopleuræ and there are distinct longitudinal rugulæ between the mesonotum and the scutellum. Ground color of the body deep reddish brown; wing insertions, posterior edge of scutellum, metanotum, and posterior borders of gastric segments deeply infuscated. Epinotal spines small, blunt and tuberculate. Petiole viewed in lateral profile not as robust, convex, or as thick antero-posteriorly as with the worker; viewed from behind subrectangular, with straight or very feebly emarginate superior border.

This new subspecies has been described from 21 workers and a dealated queen which were taken from a rotting tree branch lying on the ground at Adaton, Mississippi. Cotypes of the workers are in the collection of the Department of Entomology of the Mississippi A. & M. College, my collection, and the collection of Dr. W. M. Wheeler. The female is in my collection.

The worker of this large, yellow form is closely allied to the worker of *pergandei* as is indicated by its 12-segmented antennæ, the strong constriction between the meso-epinotum, its abundant, coarse pilosity, etc. From the worker of this species it differs however in the following respects, namely: (1) its larger size; (2) different color (yellow); (3) the less acute meso-epinotal constriction; (4) the longer, blunter and stouter epinotal spines; (5) the much larger and more convex petiole, and the distinctly broader postpetiole; (6) and lastly, in its longer, coarser, and more uneven pilosity.

I have named this new subspecies *flavus* because this is the typical ground color of the ant. Cotype specimens show considerable variation in the amount of infuscation on the body, and specimens from other nests show the color of the ant

to be highly variable, yet in spite of all this, the yellow ground color dominates—hence I have named the ant accordingly.

The ants are common at Adaton, Mississippi where they are found nesting in crevices just beneath the bark of pine stumps, near where the soil touches the stumps. Colonies appear to range in size from 50 specimens to 175 to 200 specimens. So far, only one queen has been found in a nest, though others may have been in the nest, but escaped observation. The food habits of this species are unknown.

Leptothorax (D.) pergandei floridanus spinosus var. nov.

Worker.—Length: 2.48–2.56 mm.

The worker shows its relationship to *floridanus* in that the base (dorsal surface) of the epinotum is decidedly convex and shining. The petiole when viewed laterally is very strongly convex or more node-like than with *pergandei* and lacks the central emargination on its superior border. The worker differs from the worker of *floridanus* in several characters, namely: (1) that the epinotal spines are longer and are directed upward and outward; (2) the spines are not small or tuberculate as with *pergandei* and *floridanus*, but distinctly spinose, and longer than broad at the base; (3) the pilosity is longer, coarser and more uneven; (4) the color although highly variable, is somewhat darker than that of *floridanus*. The darkest colored specimens before me, have the head, exclusive of the mandibles; the thorax, exclusive of the portion joining the head; the legs; the petiole; the postpetiole; and the gaster, exclusive of the segments from the second gastric segment to the tip, which are yellowish with dark posterior borders; black.

Described from 10 workers which were collected from a rotting pine stump at Summit, Mississippi, by Mr. L. J. Goodgame. Cotypes are in my collection, the collection of the Department of Entomology of the Mississippi A. & M. College, and the collection of Dr. W. M. Wheeler. I have named this ant *spinosus* because its epinotal spines are decidedly larger and more prominent than are the spines of the typical *pergandei* and *floridanus* and for that reason form an easy character for distinguishing it from these ants.

INSECT NUTRITION AND METABOLISM.

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At the present time, when the interest of entomologists is so sharply focused on the physiology of insects, a summary or collective review of the literature becomes a godsend. Most papers on insect physiology are distributed far and wide, often in inaccessible publications; the text-books contain only meager accounts; and the interested student experiences great difficulty in finding out exactly how much has been done. Hence a collective summary of Insect Nutrition and Metabolism, as just published by B. P. Uvarov under the auspices of the Committee on Civil Research, 2 Whitehall Gardens, London, S. W. 1., will undoubtedly be welcomed by all entomologists.

Now, it is not my purpose to write a review of this review, nor even to note its scope. My purpose is to remark politely that its chief value will lie in the bibliography, which records a trifle less than 600 titles. Nor is this note an attempt to "Condemn with polite words;" on the contrary, it is both an appreciation and a confession of disappointment.

Most every writer on subjects scientific receives a thrill when he finds his work referred to or quoted by others—that is, provided he is human. If cited incorrectly, one may shrug a patient shoulder. But if cited as sponsoring the direct opposite of what one has said—well, one is bound to reflect a bit.

Thus, on page 279 of Uvarov's summary, under the head of "The Chemical Composition of Insects and of their Products," one reads: "Lead. Traces of lead were discovered in the blood of several insects by Muttkowski (1923), and he thought that lead is a normal constituent of insect blood."

On the following page, under the caption "Arsenic," we read: "Muttkowski (1923) found traces of arsenic in insect blood, and thought it to be a normal constituent."

This sponsorship attributed to me was rather astonishing, for I could not recall that I had ever made statements of the sort. Reference to my 1923 paper is corroborative of this

opinion. For the very first sentence on page 134 of my paper contains a negation of what Uvarov claims of my work: "I have also found traces of arsenic and lead in several instances, but *can not regard them as normal constituents*," (italics mine). And further: "Both of these are cumulative poisons and it is probable that the specimens might eventually have succumbed. Still, *it is possible that* at least in the Coleopteron *Scobicia declivis*, which, according to Burke, Hartman, and Snyder (1922), pierces layers of lead in lead cables and may even build galleries in lead sheets, *a tolerance for lead has developed* and that *analyses would show the presence of lead* in the blood."

On page 281, under the caption "GENERAL OBSERVATIONS," Uvarov makes this statement: "A series of ash analyses made on a definite plan would give very valuable material for future studies in insect metabolism. In arranging the analyses special attention would require to be paid to the necessity of separating excretory products and ingested food from the actual constituent parts of the insect body. *This has never yet been done.*"

The italics are mine, and are intended to call attention to the fact that *it has been done*, and that the procedure is noted in the 1923 paper, which Uvarov repeatedly referred to. See page 132 of my 1923 paper. In briefest form, pages 132–134 then show my results of several hundred experiments on *insect blood alone*. I did not consider it needful to detail all these experiments nor the chemical methods used, as I was not writing a chemical text, but simply giving results that would be of interest to entomologists and physiologists. But then I *thought* I was making it clear that I was dealing with insect blood *solely*, and reading my sentences in this year 1929, I may say that I still think so.

Under the head of "Pigments," Uvarov summarizes the work done on blood pigments. Yet the summary leaves the impression that the respective authors got their results from the direct study of the blood or some particular tissue. Here I wish to repeat the caution of my 1923 paper: "Unfortunately, from the various studies it is not clear if whole specimens were used in the extraction of the pigments, or the blood alone. On the contrary, in a number of instances, large quantities of whole specimens are specifically mentioned as used for extraction. Yet it is a fact that the pigments as deposited in

the wings or epidermis, although originating from the blood, are elaborated substances of more complex composition, and hardly identical with those in solution in the blood."

I have not attempted to check up how other writers fared in Uvarov's summary. But even a hurried examination of the bibliography shows no reference to the work of Bishop on the Insect Fat Body, of Shinoda on Intestinal Secretion, of Yaga on Growth, of Sayle on Metabolism, of Taylor on Oxygen Consumption, of Fink on Respiratory Metabolism, Rich on Copper in Blood, and others. These writers have published prior to June, 1928, when Uvarov completed his paper.

As stated, my purpose is not "to condemn with polite words." In reviewing hundreds of papers, mistakes and inaccuracies may slip in easily, although in a summary it is particularly important to guard against such contingencies.

The papers involved in this note are:

MUTTKOWSKI, R. A. Studies on the Blood of Insects. I. The Composition of the Blood. Bull. Brooklyn Ent. Soc., 18: 128–136. 1923.

UVAROV, B. P. Insect Nutrition and Metabolism. A Summary of the Literature. Trans. Ent. Soc. London, Part II, 255–343, 1928. ("A limited number of separate copies are available on application to the Secretary, Committee on Civil Research, 2 Whitehall Gardens, London, S. W. 1.")

BOOK NOTICE.

DIE INSEKTEN. (Vol. VII of Brehm's Tierleben). By ERNST TASCHENBERG, completely revised by CARL W. NEUMANN; 544 pages, 8 colored plates and 64 black and white illustrations. Published by PHILIP RECLAM JUN., Leipzig.

This is the seventh volume of the memorial edition of Brehm's Tierleben, which was first published in 1863. This volume has been completely rewritten by Professor Carl W. Neumann. It is a semi-popular but entirely reliable account of the biology of insects. In this country it will be helpful to graduate students who wish to get a reading knowledge of entomological German. It sells in Germany at 6 marks ($1.50) in linen binding, and 8 marks ($2.00) in half leather. The last 22 pages are an index to authors quoted and to the subjects treated.

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THE FOLDED-WINGED WASPS OF THE BERMUDAS, WITH SOME PRELIMINARY REMARKS ON INSULAR WASP FAUNÆ.

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Through the whim of fashion, which affects Science as well as every other human institution, it has come to pass that in biogeographical studies the "ecological" aspect nowadays has the center of interest; while the purely "geographical," or distributional, method, as exemplified by Wallace's work, is being sadly neglected. To make matters worse, the professional "ecologist" gives undue prominence to the strictly physiological side of the problem, *viz.* the reaction of the organism to the environment. Other equally important topics of the animal's (or plant's) biology, such as food-habits, reproduction, enemies and parasites, seem hardly worthy of his attention. At the risk of being dismissed as antiquated by the prophets of the day, I am presenting this brief paper in support of the contention that "ecology" alone cannot teach us *all* the story of the present-day distribution of animals and plants.

It is, moreover, easy to discover one of the reasons why the modern biologist so often favors the ecological rather than the distributional method in the study of biogeography. Any inquiry into the actual distribution of animals or plants presupposes a first-hand knowledge of species, genera, and families. It necessarily calls for an intensive taxonomic specialization, to which many modern biologists are unwilling to submit. Even Wallace, fifty years ago, found it necessary to restrict his investigations almost wholly to the Vertebrates. The number of species has increased tremendously since that time, necessitating a growing complexity of classification. The present-day